3.0 Environmental Monitoring

Environmental monitoring efforts in the Accotink Creek watershed include benthic community sampling and analysis, habitat condition assessments, ambient water quality sampling, sediment and fish tissue sampling, toxicity testing, and discharger monitoring. Monitoring efforts presented in this chapter were conducted by the Virginia Department of Environmental Quality (VADEQ). **Figure 3-1** plots the location of the monitoring stations that were used for the analysis of the benthic impairment in Accotink Creek.

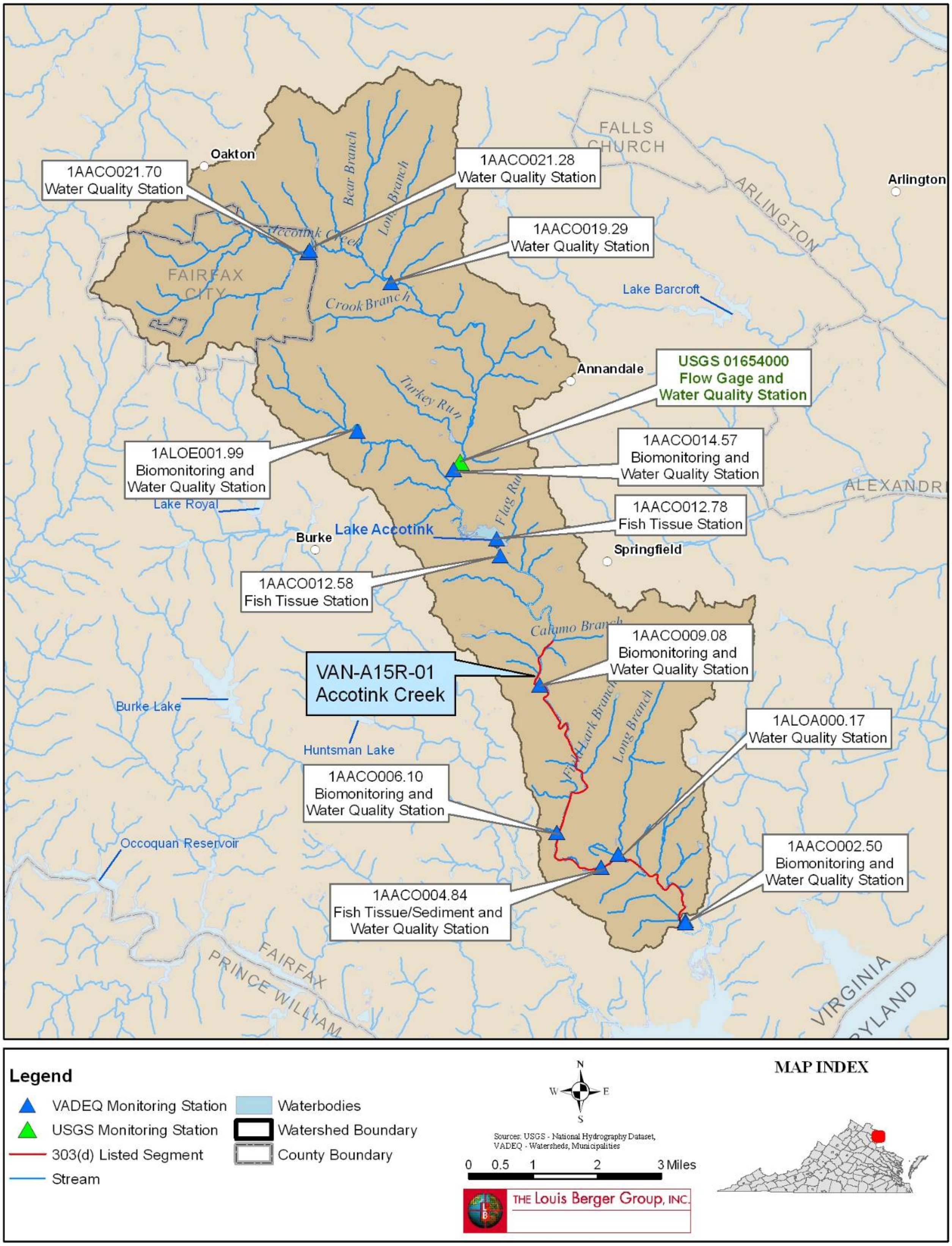

Figure 3-1: Monitoring Locations in the Accotink Creek Watershed

3.1 VADEQ Environmental Monitoring Data

The first step in benthic TMDL development is the identification of the pollutant stressor(s) impacting the benthic community. Environmental monitoring data are vital to this initial step. The following sections summarize and present the available monitoring data used to determine the primary stressor impacting the biologically impaired segment of Accotink Creek. Data analyzed included available biological monitoring data, habitat assessment data, water quality monitoring data, results from instream toxicity studies, and sediment and fish tissue sampling. **Table 3-1** gives a summary of the monitoring data collected in the Accotink Creek watershed.

Table 3-1: Inventory of VA DEQ Environmental Monitoring Data for Accotink Creek

Data Type	Monitoring Stations											
	1AACO021.70	**1AACO021.28**	**1AACO019.29**	**1AACO0014.57**	**1AACO012.78**	**1AACO012.58**	**1AACO009.08**	**1AACO006.10[1]**	**1AACO004.84**	**1AACO002.50**	**1ALOA000.17**	**1ALOE001.99**
Biological Monitoring				X			X	X		X		X
Ambient Water Quality Monitoring	X	X	X	X			X	X	X	X	X	X
Sediment and Fish Tissue Sampling					X	X			X			
Toxicity Study								X	X			
Discharge Monitoring Reports (DMR)	-											

[1]1AACO006.10 is the primary monitoring station in the lower portion of Accotink Creek and has more data than streams located downstream.

3.1.1 Biological Monitoring Data

Based on biological monitoring data, Accotink Creek was subsequently listed as impaired for benthics in the 1996 303(d) for not meeting the aquatic life use due to poor health in the benthic biological community. Accotink Creek was subsequently listed in the 1998, 2002, 2004, and 2006 Integrated 305(b)/303(d) Assessments. Biological monitoring data were collected at 1AACO006.10 from 1994 to 1996 and from 2006 to 2008. Additional biological monitoring data from 2006 to 2007 were collected at 1AACO002.50 and the trend station 1AACO0014.57. Biological monitoring data from the spring of 2008 were collected at 1AACO009.14.

Biological monitoring data was evaluated using the Virginia Stream Condition Index (VSCI) metric. Calculation of a VSCI score incorporates eight standard metrics, based on the abundance and types of macroinvertebrates present at each station. The multiple metrics evaluated together give an overall indication of ecological integrity. These bioassessment scores were compared to the biological condition of a reference condition, which for VSCI is based on an aggregate of unimpaired streams in the region. The VSCI metrics and their expected response to declining stream conditions are presented in **Table 3-2**.

Table 3-2: Metrics Used to Calculate the Virginia Stream Condition Index (VSCI)

Metrics	Expected Response to Disturbance	Definition of Metric
Taxonomic Richness		
Total Taxa	Decrease	Total number of taxa observed
EPT Taxa	Decrease	Total number of pollution sensitive Ephemeroptera, Plecoptera, and Trichoptera (EPT) taxa observed
Taxonomic Composition		
% EPT Less Hydropsychidae	Decrease	% EPT taxa in samples, subtracting pollution-tolerant Hydropsychidae
% Ephemeroptera	Decrease	% Ephemeroptera taxa present in sample
% Chironomidae	Increase	% pollution-tolerant Chironomidae present
Balance/Diversity		
% Top 2 Dominant	Increase	% dominance of the 2 most abundant taxa
Tolerance		
HBI (Family level)	Increase	Hilsenhoff Biotic Index (HBI)
Trophic Group		
% Scrapers	Decrease	% of scraper functional feeding group

An impairment cutoff score of 60.0 is used for assessing results. Streams that have a VSCI score of 60 or greater are considered to be non-impaired, while streams that score less than 60 are considered impaired.

VSCI Scores

In the Accotink Creek watershed, VSCI scores were calculated for stations 1AACO002.50, 1AACO006.10, 1AACO009.14, and 1AACO0014.57. Stations 1AACO002.50 and 1AACO006.10 are located on the impaired segment of Accotink Creek, while station 1AACO0014.57 is located upstream of the impaired segment of Accotink Creek (**Figure 3-1**). The following is a summary of the metrics used in calculating the VSCI scores

a) Taxonomic Richness

Taxa richness measures the overall variety of the invertebrate assemblage by counting the number of distinct taxa within selected taxonomic groups (Burton et. al. 2003). High taxa richness is an indicator of a healthy benthic community. At the Accotink Creek monitoring stations, the average total taxa ranged from 5 to 20 and averaged 11 distinct taxa (**Figure 3-2**). There was a slight increase of total taxa at station 1AACO006.10 between the sampling periods.

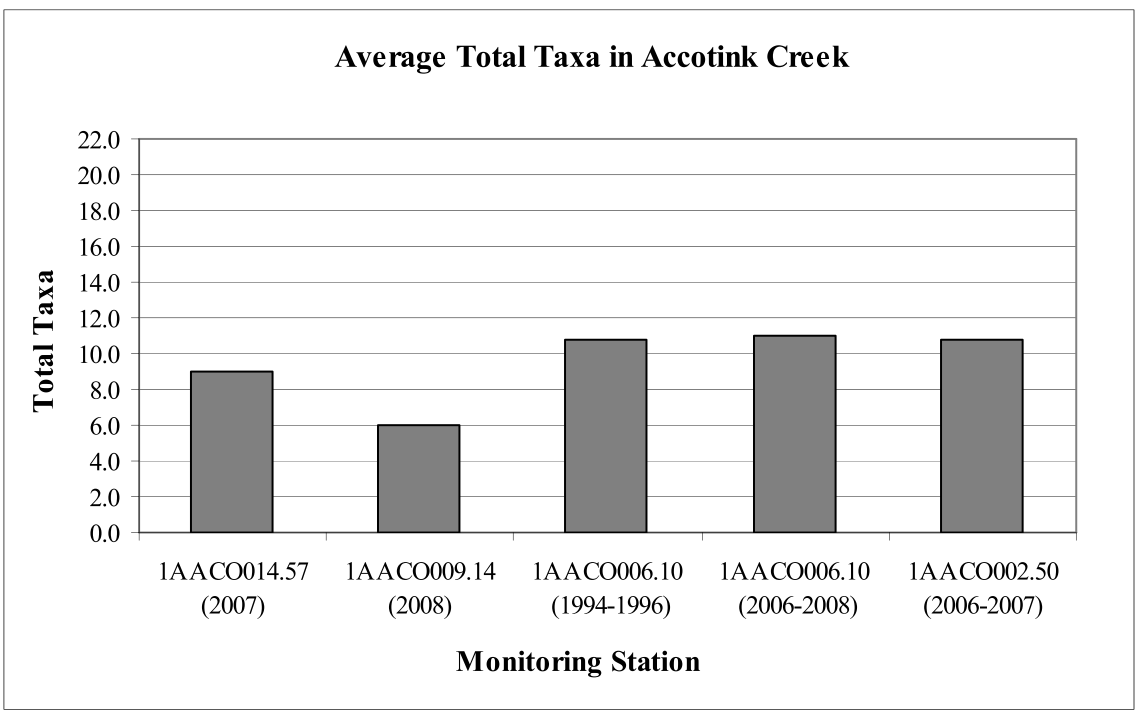

Figure 3-2: Total Taxa in the Accotink Creek

Another metric of taxonomic richness is the EPT (Ephemeroptera - mayflies, Plecoptera - stoneflies, Trichoptera - caddisflies) index. The EPT index is the number of families from the EPT orders in a sampling. Since the majority of the families in the EPT orders are intolerant of pollution and other environmental stressors, the EPT index is another indicator of benthic community health. At the Accotink Creek monitoring stations, the EPT index ranged from 1 to 3 distinct EPT taxa with an average of 2 distinct EPT taxa.

b) Taxonomic Composition

The percentage of Ephemeroptera was calculated to measure the composition mayfly nymphs within the sample. Since the majority of these species are highly sensitive to pollution and environmental stress, this metric is used as an indicator of stream health. The composition of mayflies was low in the impaired segment as well as upstream from the impaired segment (**Figure 3-3**). In the samplings conducted at station 1AACO006.10 between 1994 and 1996, the composition of mayflies ranged from 0.0% to 2.9% with an average of 0.8%. In the 2006-2008 samplings conducted at station 1AACO006.10, the composition of mayflies ranged from 0.9% to 20.0% with an average of 4.4%. At station 1AACO002.50, the percent composition of mayflies ranged from 0.0% to 11.7% with an average of 3.2%. At station 1AACO009.14, the percent composition of mayflies was 0%. At station 1AACO014.57, upstream of the impaired segment, the percent composition of mayflies ranged from 0.0% to 4.6% with an average of 2.3%.

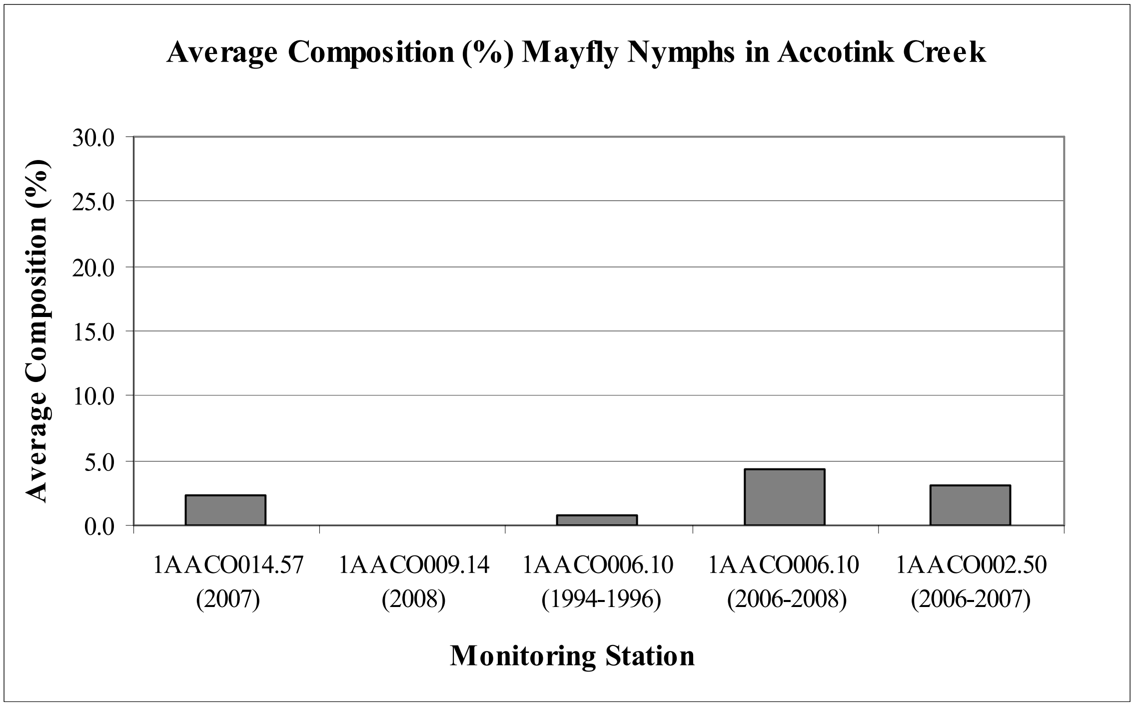

Figure 3-3: Percent Composition of Mayfly Nymphs in the Accotink Creek Watershed

The percentage of Chironomidae was calculated to measure the composition of midge larvae within the sample. Because midge larvae are tolerant to many stressors, this metric is expected to increase with increasing pollution and environmental stress. The composition of midge larvae increased from upstream to downstream in the Accotink Creek (**Figure 3-4**). There was an increase in Chironomidae at station 1AACO006.10 between the sampling periods.

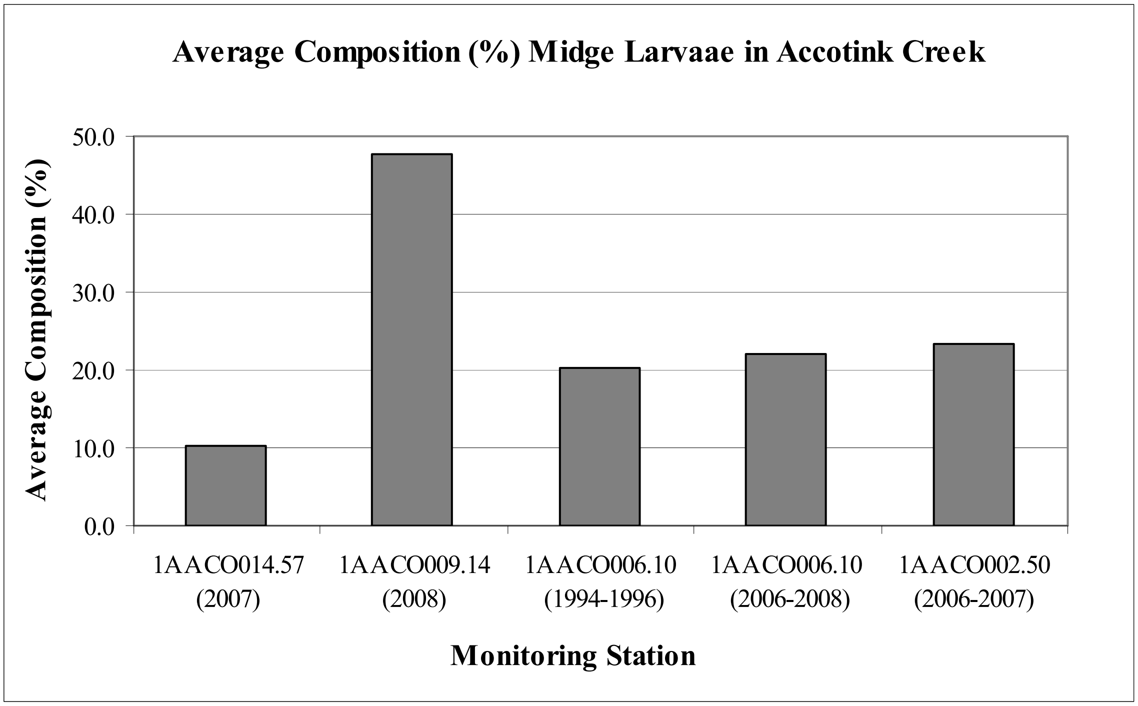

Figure 3-4: Average Percent Composition of Midge Larvae in the Accotink Creek Watershed

c) Balance and Diversity

The percentage of the two most abundant taxa was calculated as a measure of the community balance within the sample. As with taxa richness, a community in a polluted stream will most often be dominated by a few taxa. In Accotink Creek, samples from all stations were dominated by two taxa. In the samplings collected in 2006 and 2008, the percentage of the two most abundant taxa ranged from 46% to 94% with an average of 73% (**Figure 3-5**). At station 1AACO006.10, the percentage of the two most abundant taxa increased between the sampling periods.

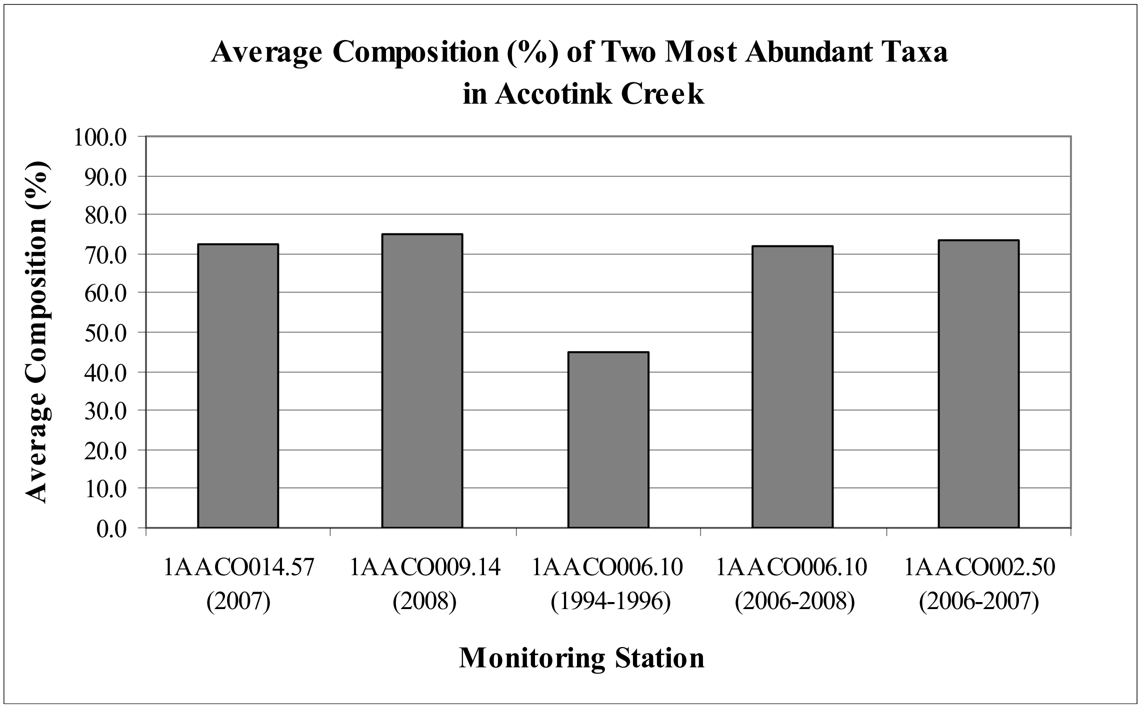

Figure 3-5: Average Percent Composition of Two Most Abundant Taxa In the Accotink Creek Watershed

d) Tolerance

The Modified Family Biotic Index (MFBI) was calculated as a measure of a macroinvertebrate community's tolerance to pollution. The MFBI is the Hilsenhoff's Biotic Index (HBI) adapted for Virginia's aquatic macroinvertebrate communities where organisms are identified to the Family level. MFBI scoring is on a scale from zero to ten, with zero indicating unpolluted conditions. In samples collected between 2006 and 2008, the MFBI scores ranged from 5.7 to 7.1 with an average score of 6.2 (**Figure 3-6**). There was a slight decrease of the MFBI score at station 1AACO006.10 between the sampling periods.

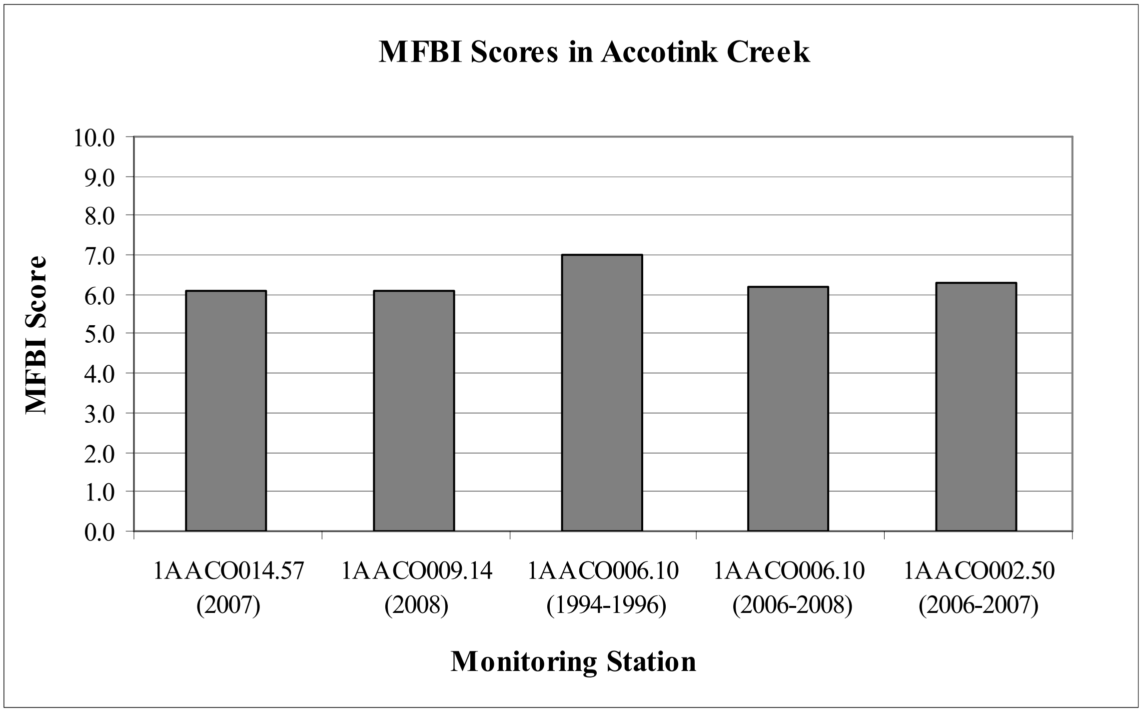

Figure 3-6: MFBI Scores in the Accotink Creek Watershed

e) VSCI Results

The data discussed in the sections above were included by VADEQ in calculating VSCI scores for the stations 1AACO002.50, 1AACO006.10, 1AACO009.14, and 1AACO014.57. **Table 3-3** shows the VSCI scores results for the stations that are discussed in this report.

Table 3-3: Virginia SCI Scores for Accotink Creek

Collection Period	1AACO002.50	1AACO006.10	1AACO009.14	1AACO014.57
Fall 1994	-	38.3	-	-
Spring 1995	-	38.9	-	-
Fall 1995	-	30.6	-	-
Spring 1996	-	38.2	-	-
Fall 1996	-	28.3	-	-
Spring 2006	35.3	24.3	-	-
Fall 2006	26.6	41.9	-	-
Spring 2007	33.5	36.6	-	31.6
Fall 2007	28.3	29.7	-	30.9
Spring 2008	-	25.7	22.8	-
Average	**30.9**	**34.8[1]/31.6[2]**	**22.8**	**31.2**

[1]Average VSCI score at 1AACO006.10 from 1994 to 1996
[2]Average VSCI score at 1AACO006.10 from 2006 to 2008

During the collection period of 1994 and 2008, VSCI scores were below the impairment cutoff of 60.0 (**Figure 3-7**) along Accotink Creek. The VSCI scores for the 2006 to 2008 samplings ranged between 22.8 and 41.9 with an average score of 30.6. At station 1AACO006.10, the VSCI scores decreased between the 2006 and 2008 sampling periods.

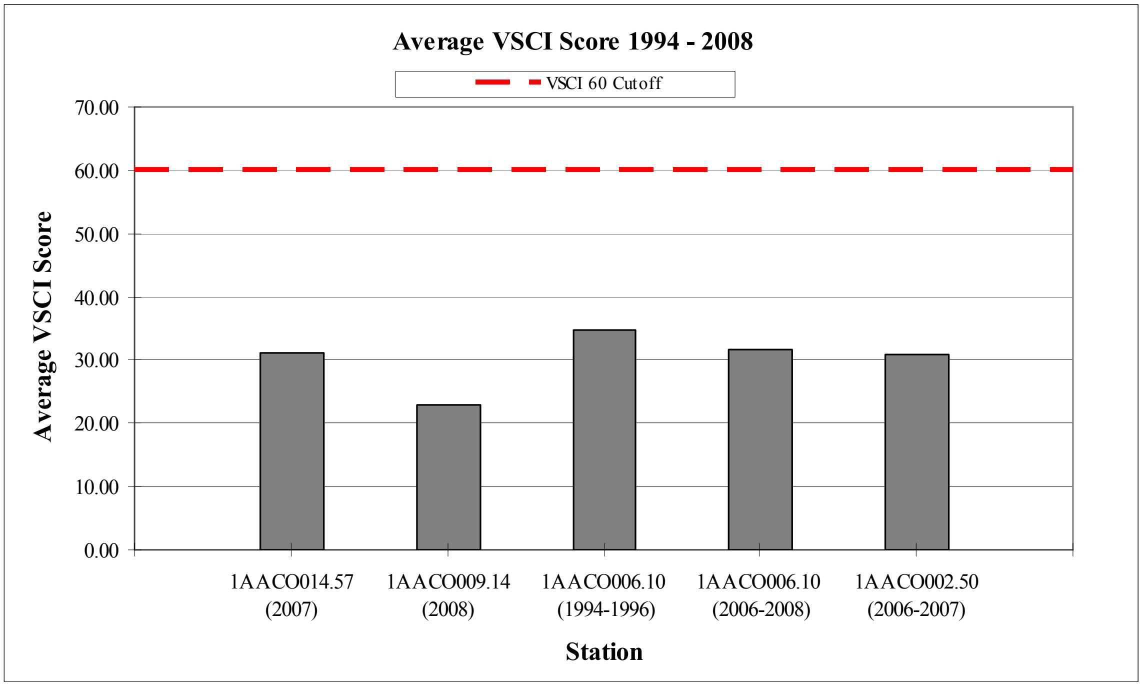

Figure 3-7: Average VSCI Scores for the Accotink Creek Watershed and Reference Station between 1994 and 2007

3.1.2 Habitat Assessment

A suite of habitat variables were visually inspected by VADEQ at monitoring stations as part of the biological assessments conducted on Accotink Creek. Habitat parameters that were examined along the impaired segment include epifaunal substrate, embeddedness, velocity, sedimentation, channel flow, channel alteration, frequency of riffles, bank stability, vegetation protection, and riparian zone. During each sampling event, parameters were assigned a score from 0 to 20, with 20 indicating optimal conditions, and 0 indicating very poor conditions. Habitat assessment scores for the biomonitoring stations in the Accotink Creek watershed are presented in **Table 3-4.**

Table 3-4: Habitat Scores for Accotink Creek Watershed												
Station	**Sampling Season**	**Epifaunal Substrate**	**Embeddedness**	**Velocity**	**Sediment Deposition**	**Channel flow**	**Channel Alteration**	**Frequency of Riffles**	**Bank Stability[1]**	**Vegetative Protection[1]**	**Riparian Zone[1]**	**Total Habitat Score**
1AACO014.57	Spring 2007	17	16	16	16	13	18	17	9	11	11	144
	Fall 2007	12	12	15	7	8	17	9	4	8	12	104
	Average	15	14	16	12	11	18	13	7	10	12	124
1AACO009.14	Spring 2008	11	12	15	12	19	16	11	10	10	10	126
	Average	11	12	15	12	19	16	11	10	10	10	126
1ACCO006.10	Fall 1994	3	14	16	8	16	10	15	14	15	5	139
	Spring 1995	9	17	17	10	17	12	15	14	16	12	160
	Fall 1995	6	17	18	11	18	10	16	16	17	10	159
	Spring 1996	11	18	18	9	18	11	16	14	17	10	162
	Fall 1996	12	17	18	15	18	12	17	16	14	14	177
	Spring 2006	8	6	12	10	12	15	12	10	12	12	109
	Fall 2006	7	4	14	6	18	11	13	10	12	9	104
	Spring 2007	13	11	15	10	10	18	15	10	18	19	139
	Fall 2007	10	10	15	7	10	17	17	7	9	16	118
	Spring 2008	7	15	17	14	19	16	16	4	6	18	132
	Average[2]	9	9	15	9	14	15	15	8	11	15	120
1AACO002.50	Spring 2006	8	8	13	6	9	14	7	8	12	14	99
	Fall 2006	3	2	15	2	17	4	13	7	10	18	91
	Spring 2007	13	11	15	10	12	17	11	10	20	20	139
	Fall 2007	8	10	15	5	8	17	16	7	11	18	115
	Average	8	8	15	6	12	13	12	8	13	18	111

[1]The total score is presented here. The left and right banks are scored separately.
[2]Average scores for 2006-2008 samplings

Overall, habitat assessment scores from 2006 and 2008 were generally low at all stations on Accotink Creek with scores ranging between 91 and 144 with an average score of 118. Scores for habitat metrics such as epifaunal substrate, embeddedness, sediment deposition, and bank stability, were consistently low for the stations on the impaired segment of Accotink Creek (**Figure 3-8**). The following is a summary of the four habitat metrics that scored low:

- The epifaunal substrate metric is a measure of the relative quantity and variety of natural structures in the stream for spawning and nursery functions of aquatic macrofauna. In Accotink Creek, scores from the 2006 and 2008 samplings ranged between 3 and 17 with an average score 10. Earlier samplings at station 1AACO006.10 also yielded similar scores.

- The embeddedness metric is the extent to which rocks and snags are covered or sunken in silt, sand, or mud in the stream bottom. In Accotink Creek, scores from the 2006 and 2008 ranged between 2 and 16 with an average score of 10. Scores from earlier samplings at 1AACO006.10 were much higher, ranging between 14 and 17 with an average of 17.
- The sediment deposition metric is the amount of sediment that accumulated in pools and the changes that have occurred to the stream result. Lower scores would indicate large-scale movement of sediment is occurring in the stream. Sediment deposition scores from the 2006-2008 samplings ranged from 2 to 16 with an average of 8. Earlier samplings at 1AACO006.10 yielded similar scores with a range between 8 and 15 and an average score of 11.
- The bank stability metric is the measure whether stream banks have eroded or have the potential for erosion. Scores from the 2006-2008 samplings ranged between 4 and 10 with an average of 8.2. Earlier samplings at 1AACO006.10 slightly higher scores with a range between 14 and 16 and an average score of 15.

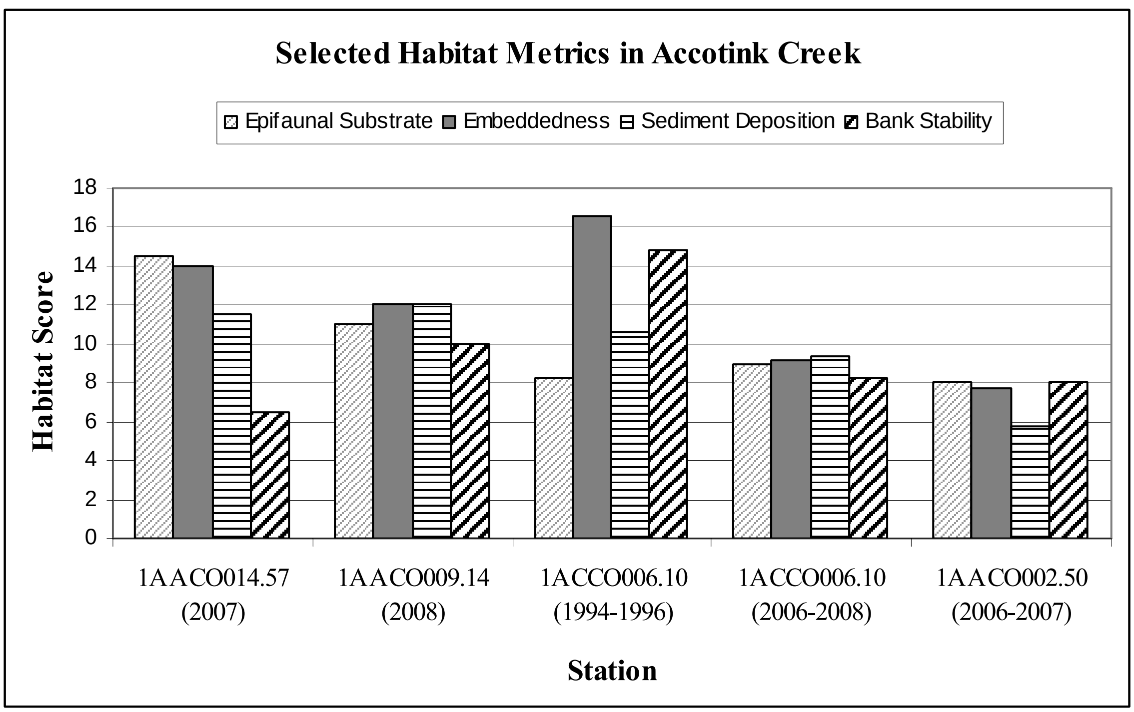

Figure 3-8: Average Habitat Scores for the Selected Metrics

The following are notes taken by VADEQ biologists during the habitat assessment.

- Fall of 1994 - Watershed heavily impacted by NPS pollution. Evidence of substrate scouring, low organism densities, and reduced taxa, notably EPT
- Spring of 1995 - Impacted from stormwater dishcharges and heavy development of watershed (typical of streams in Northern Virginia)
- Fall of 1995 - Continual impacts from storm sewer runoff are responsible for reduced benthic fauna in this heavily urbanized watershed
- Fall of 1996 - Urban NPS continue, and will continue, to impact water quality in heavily urbanized watershed

3.1.3 Relative Bed Stability Studies

Excess sedimentation is one of the most prevalent and harmful stressors to benthic macroinvertebrate communities (VDEQ 2008, ODEQ 2007, Van Sickle 2006, USEPA 2006). Until recently, tools for rapidly quantifying sedimentation impacts in streams have been inadequate. Methods existed for describing dominant particle size, but it was difficult to differentiate between natural conditions and man-made problems. Virginia has a variety of stream types; many are naturally sand/silt bed streams, so simply measuring the size of the sediment particles cannot differentiate natural and human-influenced sediment load.

United States Environmental Protection Agency (USEPA) researchers have developed a tool for predicting the expected substrate size distribution for streams (Kaufmann 1999, Kaufmann 2008). This method incorporates stream channel shape, slope, flow and sediment supply. The method calculates a ‘stream power’ based on channel measurements to predict the expected sediment size distribution. The logarithm ratio of the observed sediment to the expected sediment is a measure of the relative bed stability (LRBS). LRBS numbers around zero indicate the stream is stable (i.e. the stream is carrying the appropriate mean particle size for its calculated stream power). Increasingly negative LRBS numbers indicate excess sediment, while positive LRBS numbers signify sediment removal. This sediment removal leads to “stream hardening” which may indicate a stream that has eroding banks and an altered hydrology that affects the stream bottom. Another example of “stream hardening” occurs just downstream of some large reservoir projects. The reservoir acts as a large sediment trap, leaving the downstream river reach abnormally devoid of sediment.

2008 LRBS Data Collection on Accotink Creek

DEQ conducted an initial Relative Bed Stability (RBS) study on Accotink Creek at Station 1AACO006.10 at Route 790 (Alban Road) in November 2006. To further aid in TMDL development, follow-up RBS studies were conducted at three sites along Accotink Creek in June 2008: Station 1AACO004.84 at Route 611 (Telegraph Road), Station 1AACO006.10 at Route 790 (Alban Road), and Station 1AACO009.08 at Route 636 (Hooes Road).

The data collected by DEQ on Accotink Creek allows the calculation of several quantitative habitat metrics. These metrics include percent slope in reach, mean particle size, logarithm Relative Bed Stability, and percent fines (particles less than 2 mm). Quantitative habitat metrics can be compared to statewide distributions (**Figure 3-9**) calculated from Virginia’ Freshwater Probabilistic Monitoring Program (VDEQ 2008). This allows the data collected from Accotink Creek to be compared statewide.

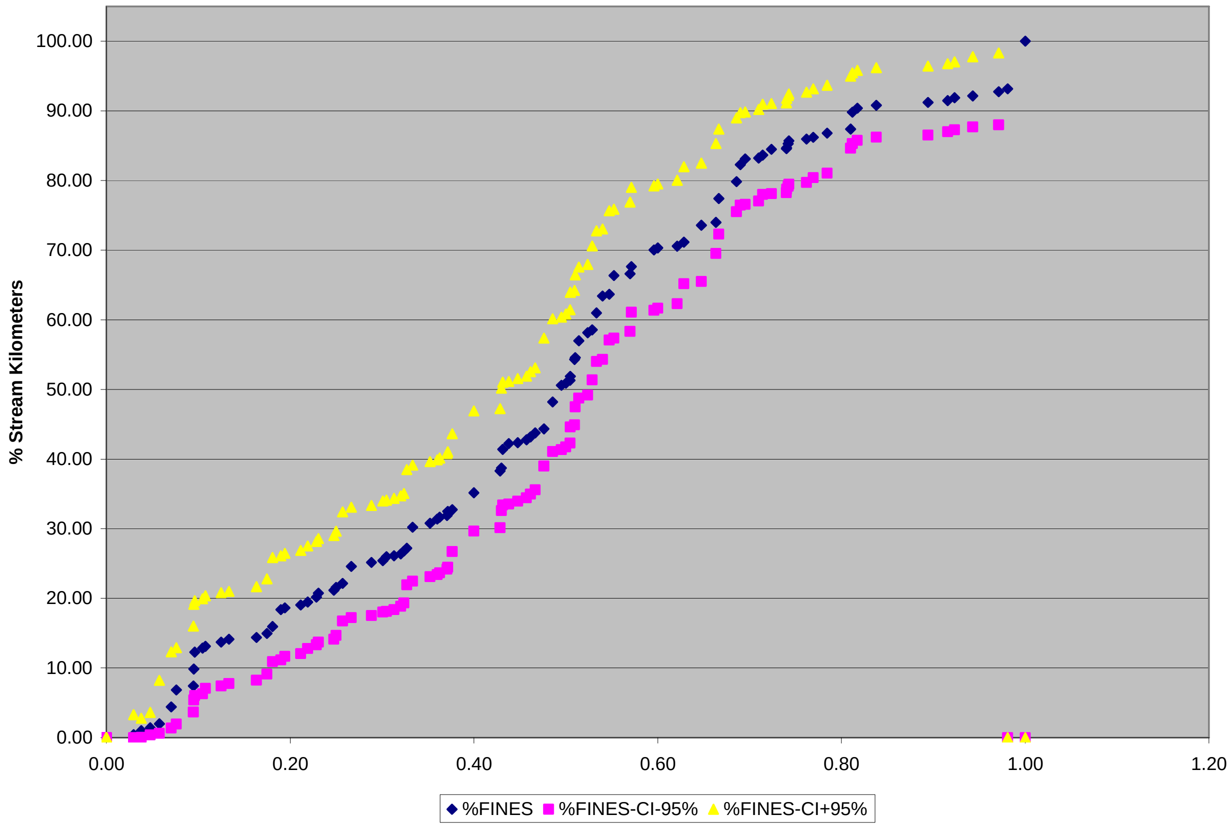

Figure 3-9: Cumulative Distribution Function of Percent Fines (particles less than 2 mm) in Virginia

The mean sediment particle size in Accotink Creek at stations 1AAC006.10 and 1AAC009.10 is within the cobble (64 to 250 mm) range (**Figure 3-10**). The sediment mean particle size in the upper Accotink stations is greater than the average mountain ecoregion stream (Hill Memo, 2007). These particle sizes are in the upper quartile statewide. At station 1AAC004.84 the mean particle size is closer to course gravel.

Table 3-5: Mean Particle Size Percentile in Accotink Creek

Station ID	Mean Particle Size	Percentile
1AAC004.84	1.17	73rd
1AAC006.10 (2006)	1.57	98th
1AAC006.10 (2008)	1.35	79th
1AAC009.08	1.44	83rd

Figure 3-10: Example of Mean Particle Size Commonly Found Along the Impaired Reach of Accotink Creek. June 2008 RBS Study, Station 1AACO006.10

The LRBS at stations 1AAC006.10 and 1AAC009.08 are some of the most positive LRBS numbers recorded statewide (**Table 3-6**). The lower station 1AAC004.84 is more normal, although high for LRBS scores in Virginia. Positive LRBS numbers indicate the stream has less sediment than expected based on the stream morphology.

Table 3-6: LRBS Percentile in Accotink Creek.

Station ID	LRBS	Percentile
1AAC004.84	-0.04	88th
1AAC006.10 (2006)	0.55	98th
1AAC006.10 (2008)	0.56	95th
1AAC009.08	0.72	99th

The percent fines are in the lower quartile statewide (**Table 3-7**). These numbers are particularly low for piedmont ecoregion streams and lower than the average mountain ecoregion stream (Hill Memo 2007).

Table 3-7: Percent Fines Percentile in Accotink Creek.

Station ID	Percent Fines	Percentile
1AAC004.84	18%	15th
1AAC006.10 (2006)	19%	18th
1AAC006.10 (2008)	24%	20th
1AAC009.08	19%	18th

High slope streams in the western mountains of Virginia explain some naturally high LRBS scores (**Table 3-8**). High slope streams tend to have higher stream powers and are consequently dominated by larger particle sizes. Accotink Creek's slope is moderately low and does not explain these excessively stable LRBS numbers.

Table 3-8: Slope Percentile in Accotink Creek

Station ID	Slope	Percentile
1AAC004.84	0.52	30th
1AAC006.10 (2006)	0.22	14th
1AAC006.10 (2008)	0.17	11th
1AAC009.08	0.22	14th

Analysis of Relative Bed Stability Results:

Analysis of the relative bed stability studies indicate that altered hydrology has led to a scoured, eroded stream, which leaves behind a higher than expected median particle size (**Figure 3-11**).

Figure 3-11: Stream Bank Erosion Typical of Accotink Creek. June 2008 RBS Study, Station 1AACO004.84

In addition, it appears that fine sediment has been transported out of the upper reaches of Accotink Creek, which led to some of the highest LRBS scores in the Virginia RBS habitat database. Sediment that erodes from the banks of Accotink Creek along the impaired segment is deposited further downstream in the Accotink Watershed, closer to the tidal boundary (**Figures 3-12** and **3-13**).

Figure 3-12: Coarse Gravel and Sediment Deposits at Station 1AACO004.84 (Telegraph Road)

Figure 3-13: Fine Sand Deposit Located Under the Route 1 Bridge over Accotink Creek, near the Tidal/Non-tidal boundary

3.1.4 Ambient Water Quality Monitoring

For the purpose of this study, water quality monitoring stations through the Accotink Creek watershed were used in the development of this TMDL (**Table 3-9**). VADEQ collected instream water quality measurements for field obtained parameters such as temperature, dissolved oxygen (DO), pH, and specific conductance, and lab obtained parameters such as nutrients, solids, metals, and organic contaminants. The river sediment measurements included metals and organics. For the analysis, only data collected since 1996 was analyzed and compared to VADEQ water quality standards (DEQ, 2007) to consider the last 12 years of measurements.

Table 3-9: Water Quality Monitoring Stations Used for the Benthic TMDL

Station ID	Station Description	First Sample Date	Last Sample Date
1AACO002.50	Route 1	5/9/2005	6/12/2006
1AACO004.84	Route 611 (Telegraph Rd)	8/11/2005	6/4/2007
1AACO006.10	Route 790	10/17/1990	5/30/2008
1AACO009.08	Route 636 (Hooes Rd)	5/30/2008	5/30/2008
1AACO014.57	Route 620	9/19/1974	10/1/2008
1AACO019.29	Route 699	8/11/2005	8/11/2005
1AACO021.28	Route 237 (Pickett Rd)	5/22/2002	6/19/2002
1AACO021.70	Accotink Creek at Old Lee Highway	2/15/2006	2/15/2006
1ALOE001.99	Downstream from Route 651 (Guinea Rd)	6/1/2006	9/19/2006
1ALOA000.17	Route 611	5/4/1982	6/4/2007

A summary of measured instream data is presented below:

- DO data presented in **Figure 3-14** indicate that adequate levels of DO are found along the mainstem of Accotink Creek. The DO values for Accotink Creek range from 5.0 to 16.0 mg/L. Neither VADEQ criteria (Daily Average Limit of 5 mg/L, Minimum Limit of 4 mg/L) were exceeded.

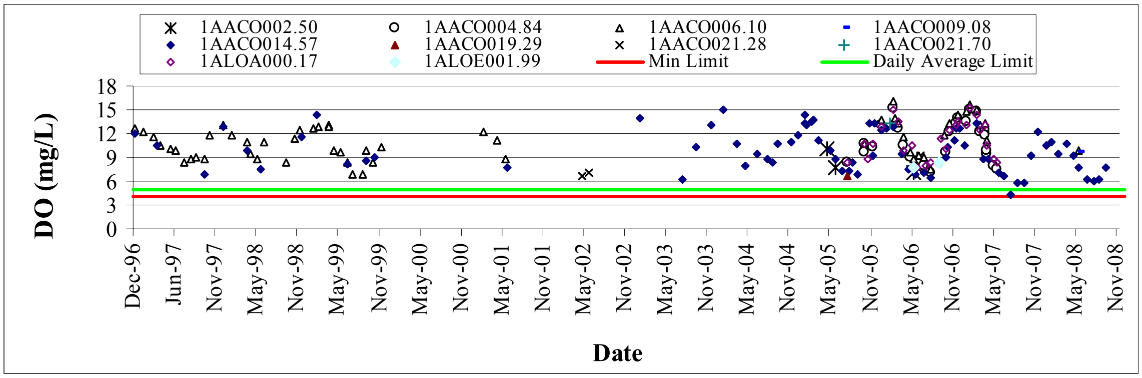

Figure 3-14: Ambient Dissolved Oxygen in Accotink Creek

- All field pH values were in compliance with VADEQ criteria (6.0 to 9.07 Standard Units) (**Figures 3-15**). pH ranged from 6.3 to 8 Standard Units.

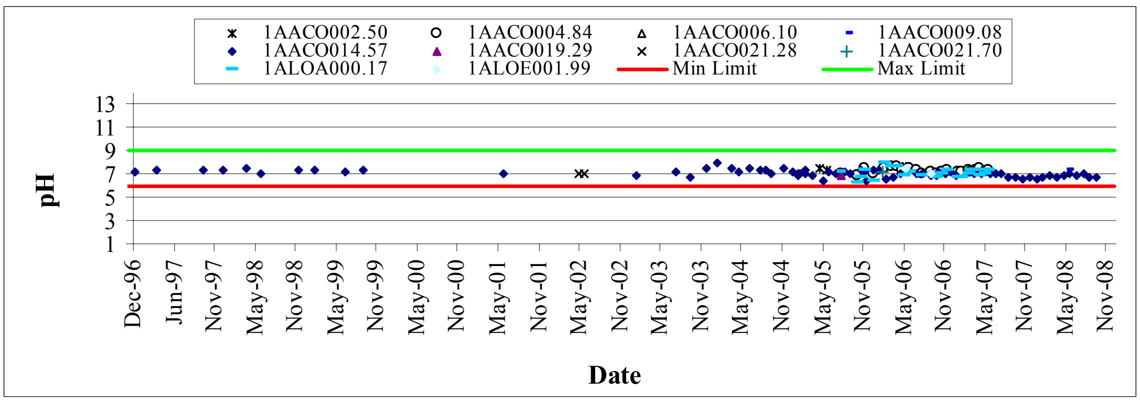

Figure 3-15: Ambient pH in Accotink Creek

- All temperature values (range of 0 to 28.5 ^{o}C) were in compliance with VA DEQ criterion of a max of 32 ^{o}C (**Figure 3-16**).

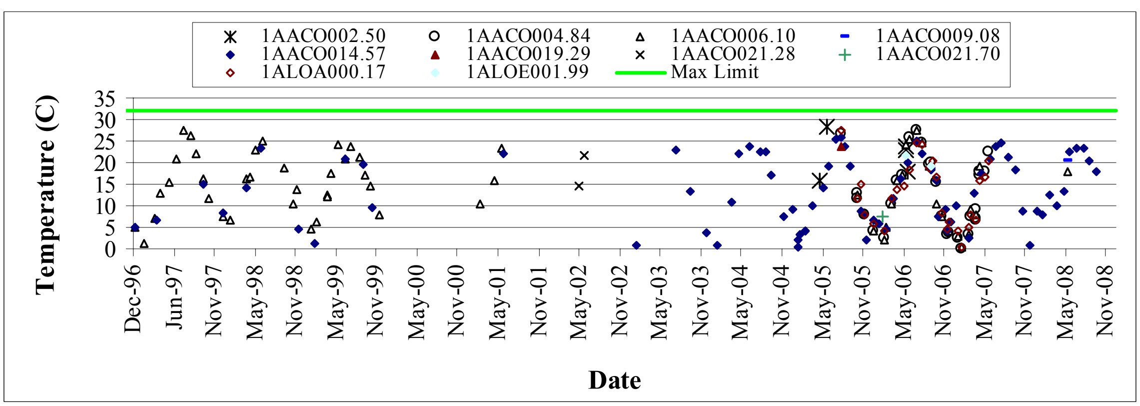

Figure 3-16: Ambient Temperature in Accotink Creek

➢ Specific conductance levels measured at all stations ranged from 98 to 4,901 µmhos/cm (total average: 369 µmhos/cm) (**Figure 3-17**).

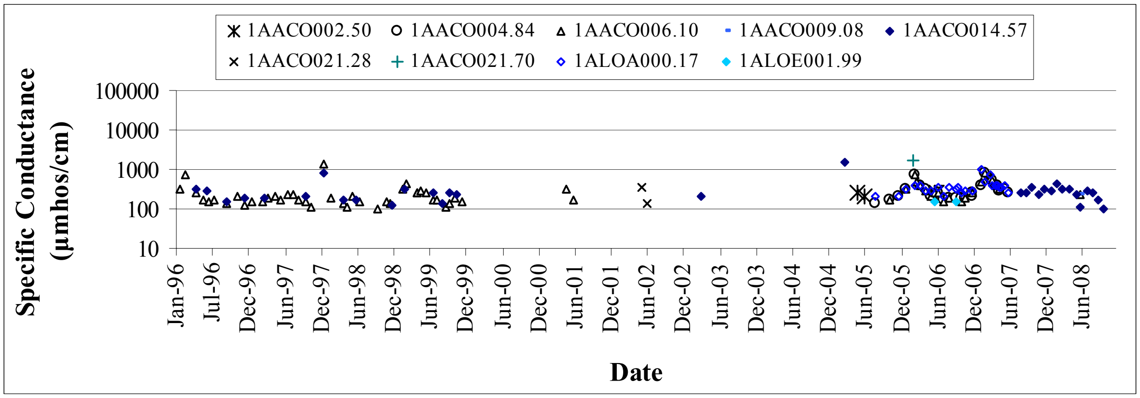

Figure 3-17: Ambient Specific Conductance in Accotink Creek

➢ Biochemical oxygen demand (BOD_5) concentrations ranged from 1.0 to 10.0 mg/L (total average: 2.43 mg/L) (**Figure 3-18**).

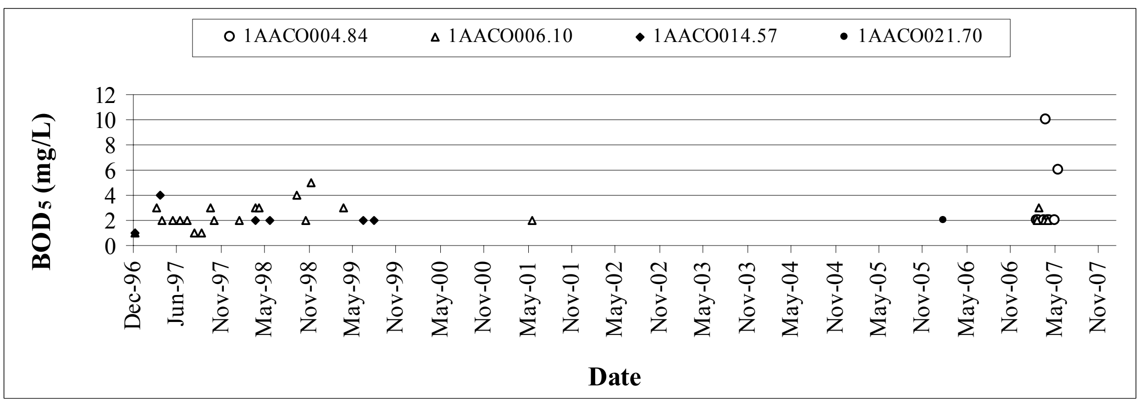

Figure 3-18: Ambient BOD_5 in Accotink Creek

➢ Chloride concentrations ranged from 7.7 to 437 mg/L (total average: 293.7 mg/L) (**Figure 3-19**). The VADEQ criteria for chloride is established at 860 mg/L (Acute) and 230 mg/L (Chronic). Chloride concentrations exceeded the chronic criterion on six occasions; twice at station 1AACO014.57, and four times at station 1AAC006.10. Elevated chloride levels occurred most often in late winter and spring months.

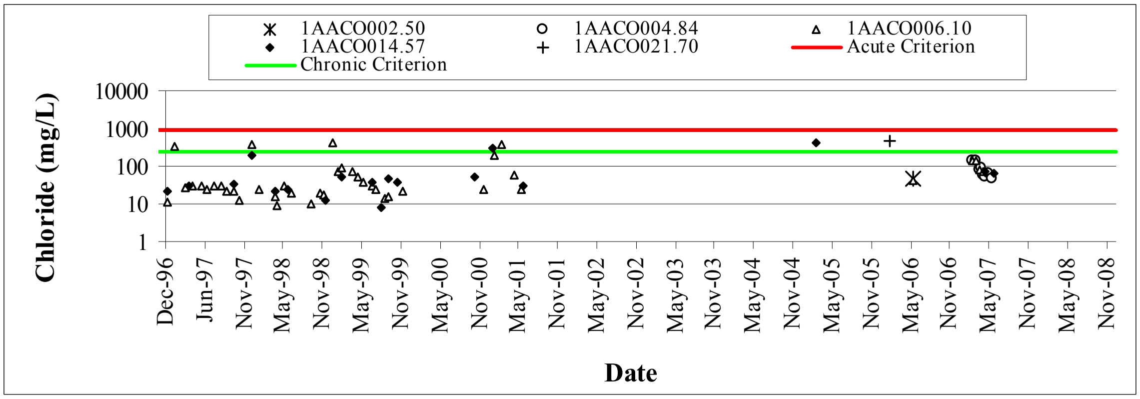

Figure 3-19: Ambient Chloride in Accotink Creek

- Total suspended solids (TSS, total non-filterable residue) concentrations ranged from 3 to 134 mg/L (total average: 16 mg/L) (**Figure 3-20**). **Figure 3-21** temporally compares TSS levels to flow conditions. The flow data was based on ambient measurements at USGS station 01654000 near Annandale, VA. There are no VADEQ screening values for TSS levels, but the majority of elevated TSS occurrences corresponded with high flow conditions in the stream. These occurrences were caused by rainstorm events.

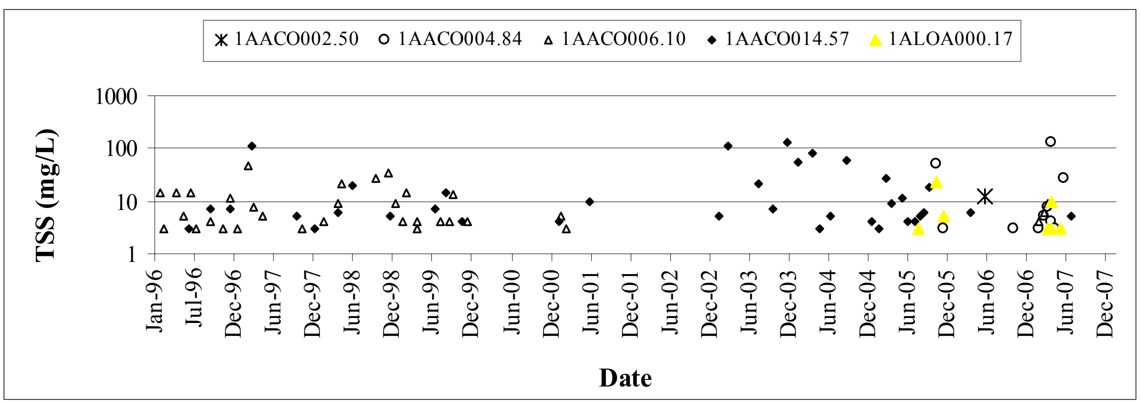

Figure 3-20: Ambient TSS in Accotink Creek

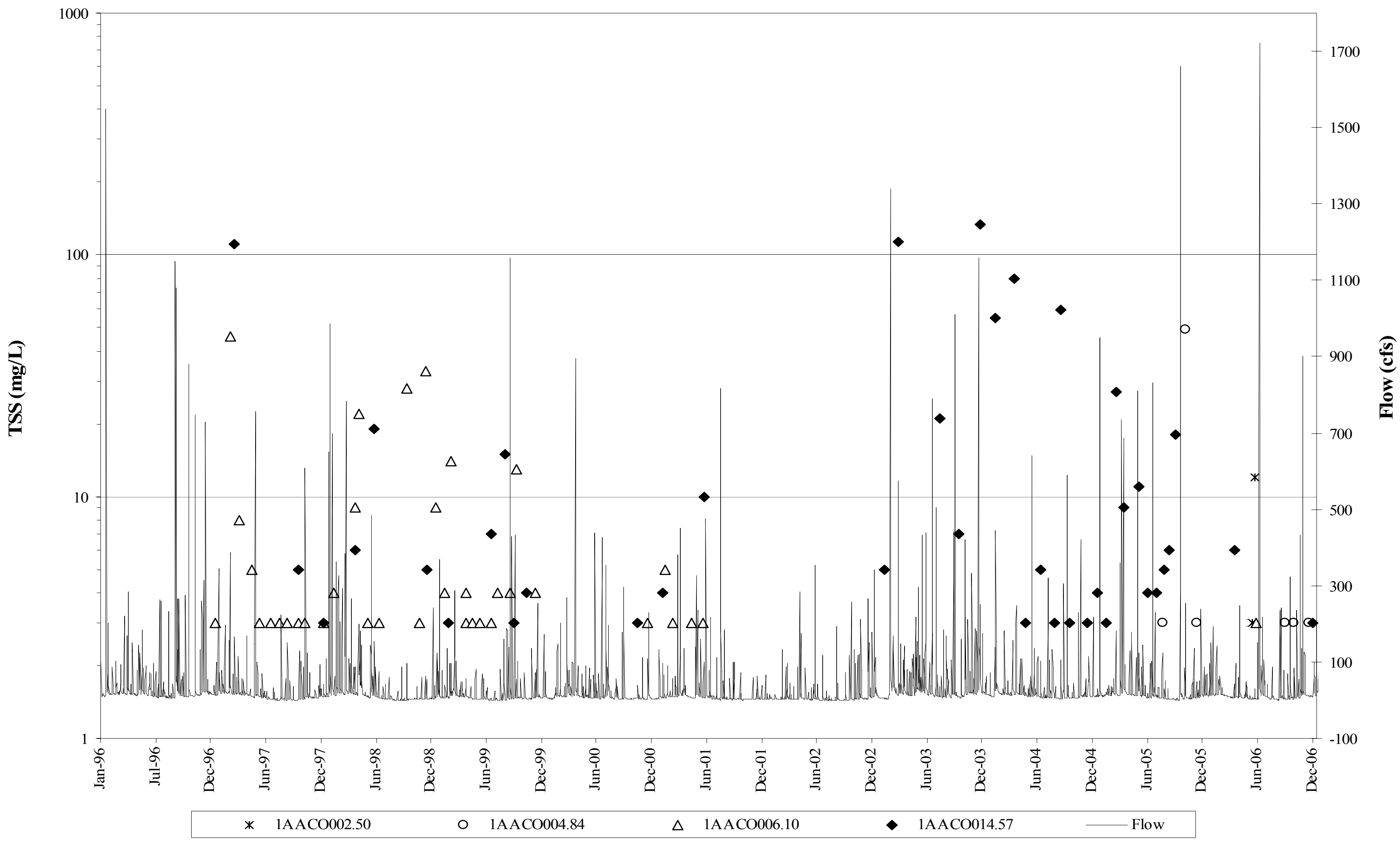

Figure 3-21: Ambient TSS and Flow in Accotink Creek between 1996 and 2006

- All total ammonia concentrations were in compliance with VA DEQ criteria, with a range of 0.40 to 0.34 mg/L (total average: 0.10) (**Figure 3-22**).

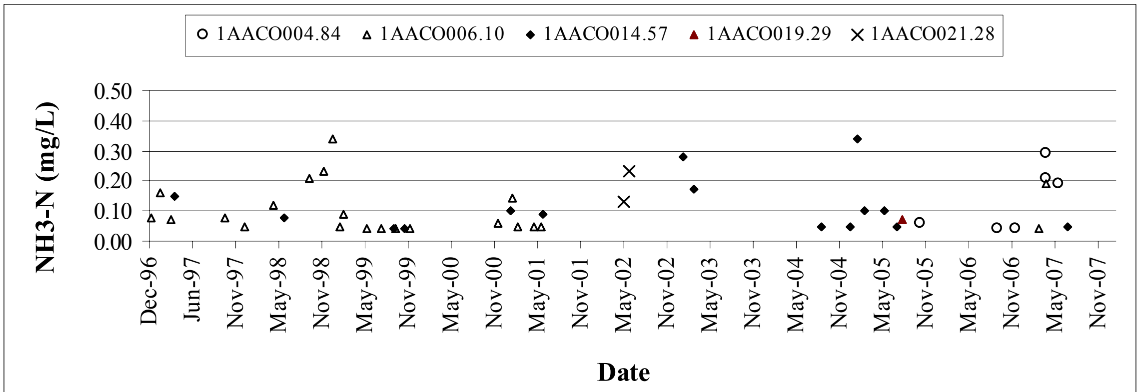

Figure 3-22: Ambient Total Ammonia in Accotink Creek

- Nitrate (NO_3-N) concentrations were generally low. NO_3-N ranged from 0.50 to 41.0 mg/L (total average: 1.1 mg/L) (**Figure 3-23**)

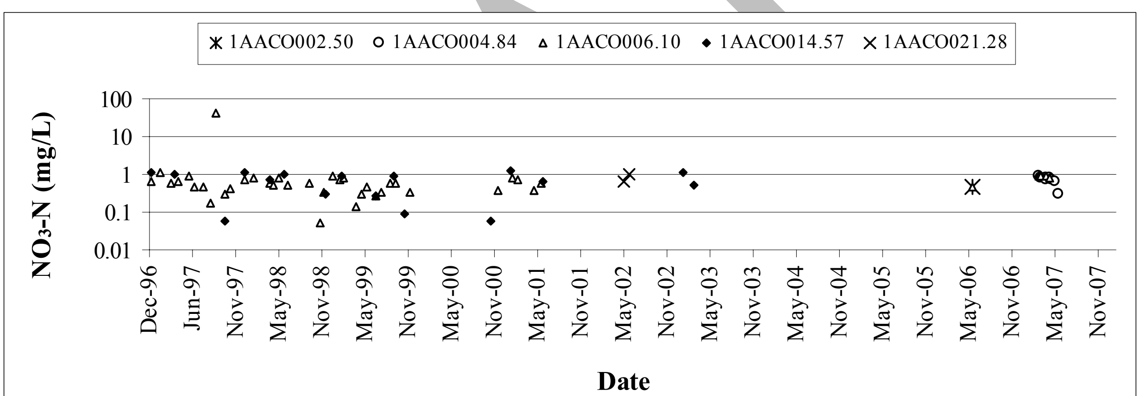

Figure 3-23: Ambient Nitrate in Accotink Creek

- Total nitrogen (TN) ranged from 0.45 to 2.8 mg/L (total average: 1.1 mg/L). Highest nitrogen levels were observed at station 1AACO004.84 (**Figure 3-24**).

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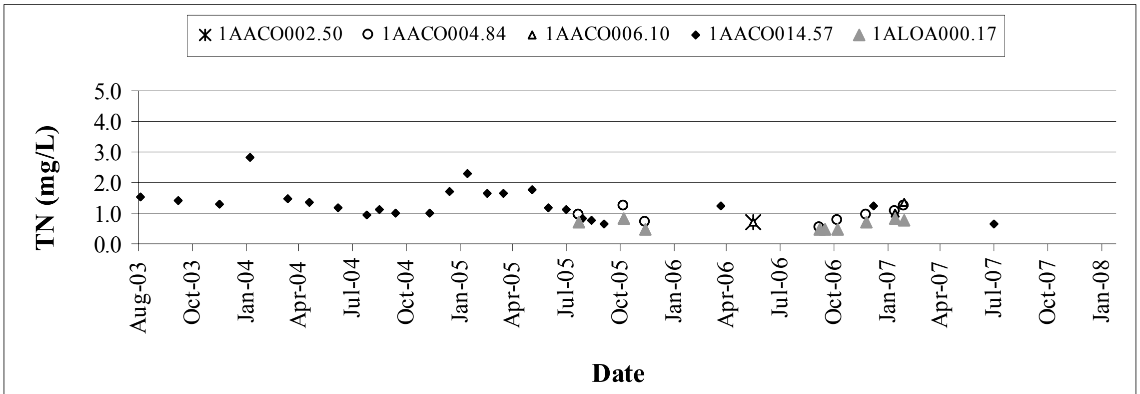

Figure 3-24: Ambient Total Nitrogen in Accotink Creek

- Ortho-phosphorus (PO_4-P) concentrations ranged between 0.01 and 0.13 mg/L (total average: 0.03 mg/L) (**Figure 3-25**).

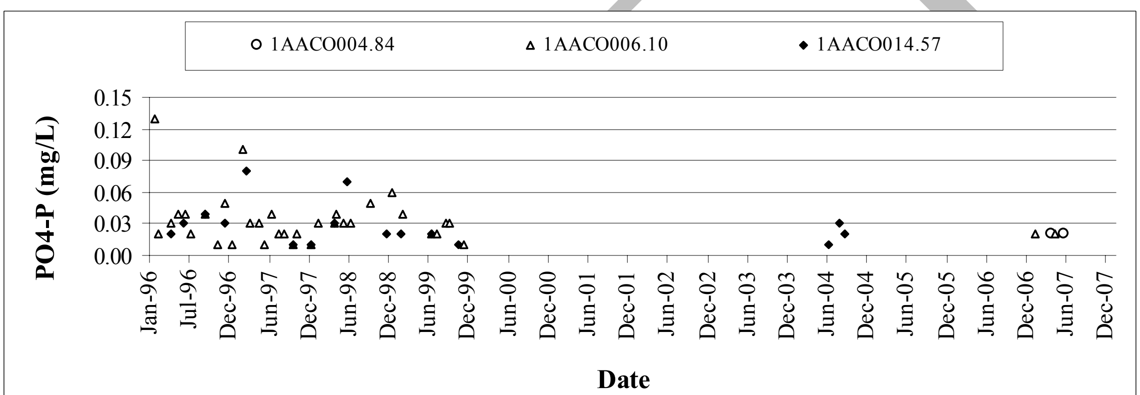

Figure 3-25: Ambient Ortho-phosphorus in Accotink Creek

- Total phosphorus levels ranged from 0.01 to 0.22 (total average: 0.05mg/L) (**Figure 3-26**).

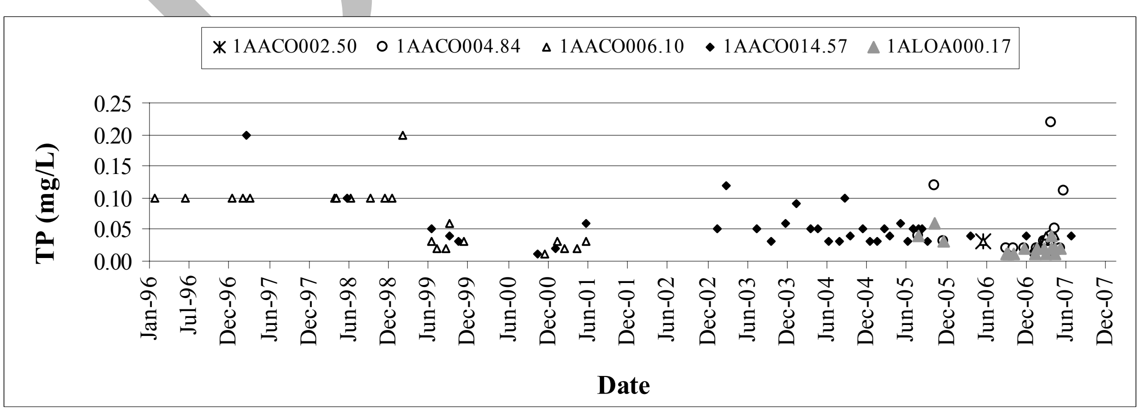

Figure 3-26: Ambient Total Phosphorus in Accotink Creek

- Phytoplankton chlorophyll *a* was only measured once at stations 1AACO002.50 and 1AACO006.10 in 2006 and twice at station 1AACO014.57 in 2003. Chlorophyll *a* values ranged from 0.6 to 21.2 µg/L with an average of 5.9 µg/L.

3.1.5 Metals Data

Dissolved metals concentrations were measured at monitoring stations 1AACO002.50, 1AACO004.84, and 1AAC006.10 within the benthic impaired segment, and at 1AACO014.57, upstream of the benthic impaired segment. Metals measured included aluminum, beryllium, cadmium, chromium, copper, iron, lead, manganese, mercury, nickel, selenium, silver, thallium, and zinc. All available dissolved metals data were assessed to determine compliance with Virginia's established water quality standards. No monitored metals parameters exceeded the acute or chronic dissolved freshwater criteria specified in Virginia's aquatic life use standards for dissolved metals.

3.1.6 Organic Contaminant Data

Instream organic contaminant data were collected at monitoring stations 1AACO002.50, 1AACO004.84, 1AAC006.10 and 1AACO014.57. Organic contaminants measured included aldrin, dieldrin, chlordane, dicofol, endrin, dichlorodiphenyltrichloroethane (DDT), dichlorodiphenyldichloroethane (DDD), dichlorodiphenyldichloroethylene (DDE), heptachlor epoxide, heptachlor, and polychlorinated biphenyls (PCBs). No monitored organic contaminant parameters exceeded the acute or chronic dissolved freshwater criteria specified in Virginia's aquatic life use standards.

3.1.7 Continuous Ambient Instream Monitoring

VADEQ conducted continuous instream measurements for temperature, dissolved oxygen, pH, and specific conductivity at one VADEQ monitoring station (1AAC006.10) in the Accotink Creek watershed over five days in August of 2006 (**Table 3-10**, **Figure 3-27 to 3-31**). The DO fluctuation over 24 hours ranged from 0.96 to 2.16 and averaged 1.47 mg/L during this time period. There were no exceedances of the minimum criterion (4 mg/L). The decrease in specific conductance seen in **Figure 3-31** is due to a rainfall event that occurred on the morning of August 7th.

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Table 3-10: Summary of Instream Continuous Measurements Over Five Days in the Benthic Impaired Segment of Accotink Creek					
	Temp	DO	DO	pH	Spec. Cond
	°C	mg/L	%	-	µS/cm
Average	27.0	6.9	86.1	7.3	219.8
Minimum	22.8	5.8	74.4	6.7	54.0
Maximum	30.1	8.6	100.0	7.5	248.0

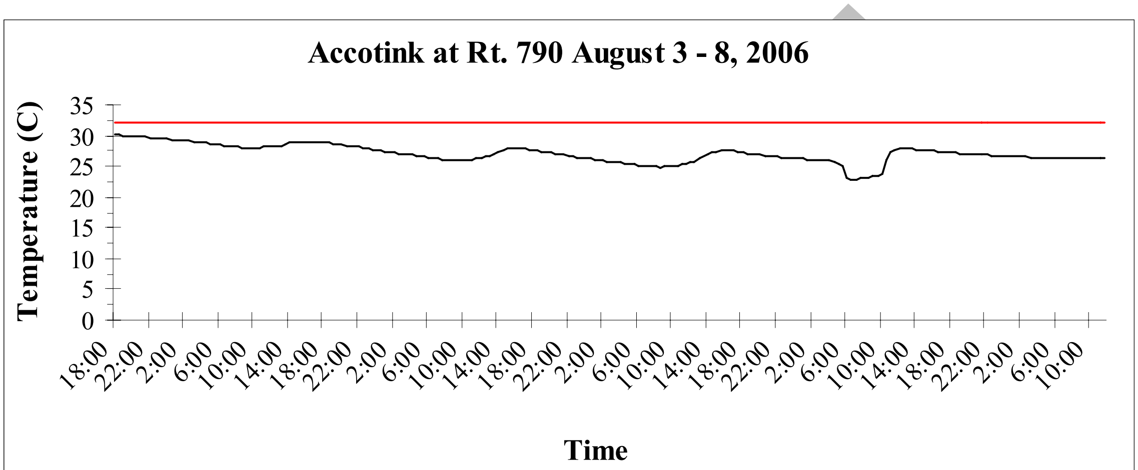

Figure 3-27: Continuous Ambient Monitoring of Temperature in Accotink Creek in August of 2006

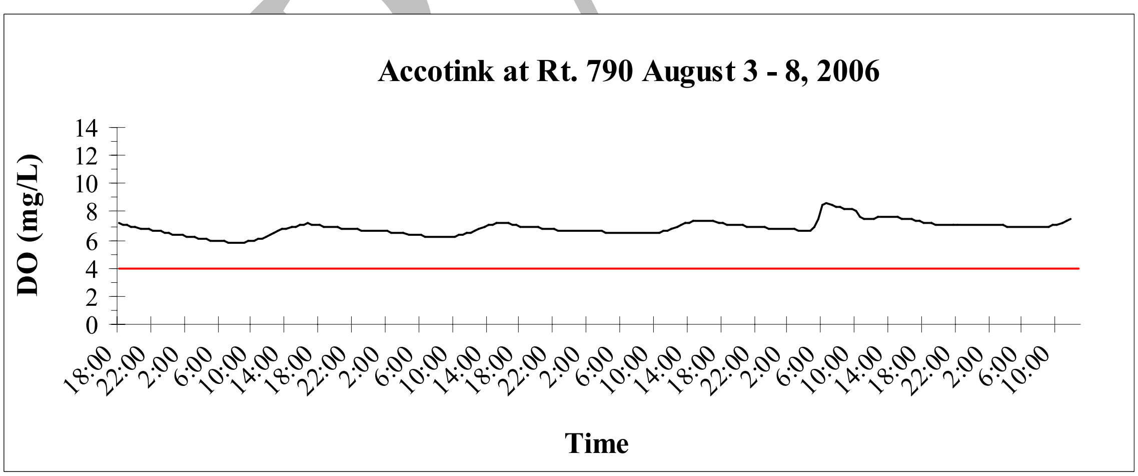

Figure 3-28: Continuous Ambient Monitoring of Dissolved Oxygen in Accotink Creek in August of 2006

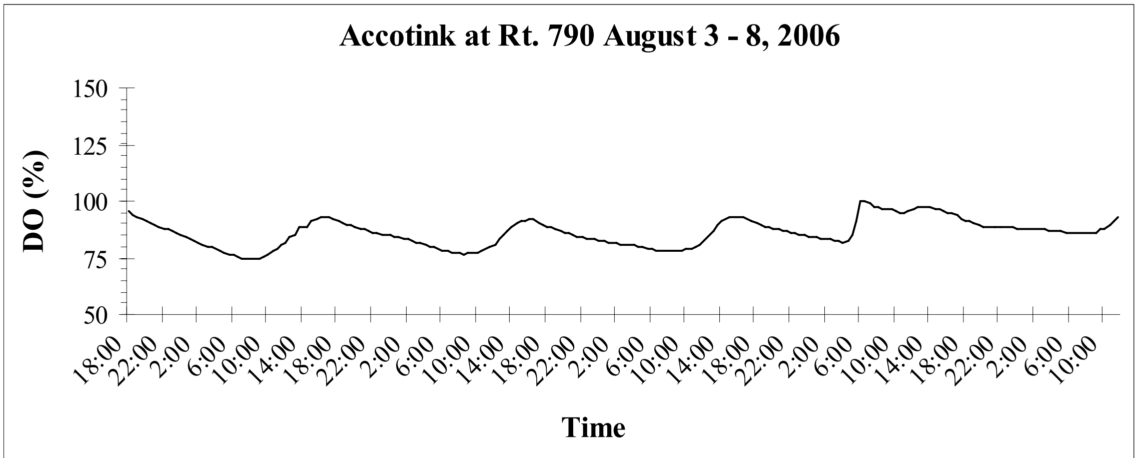

Figure 3-29: Continuous Ambient Monitoring of Dissolved Oxygen in Accontink Creek in August of 2006

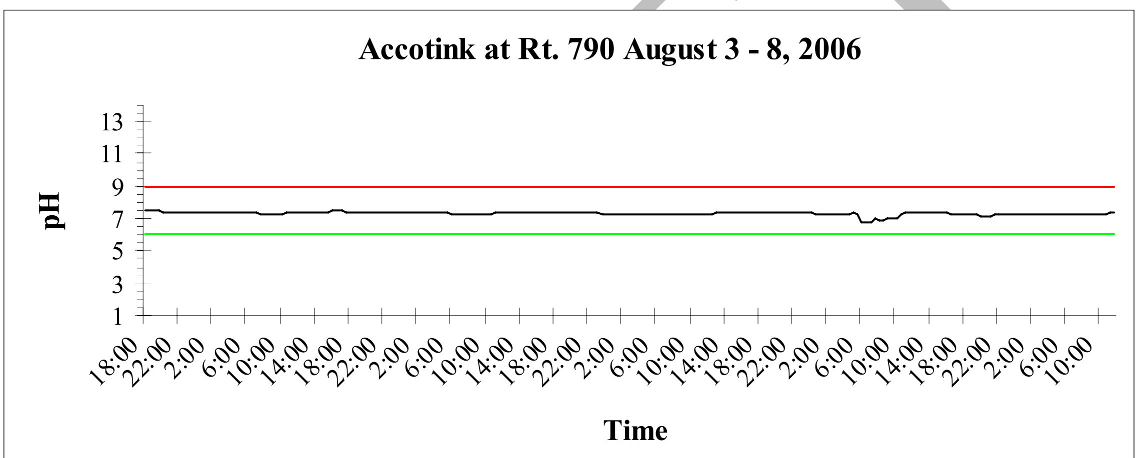

Figure 3-30: Continuous Ambient Monitoring of pH in Accotink Creek in August of 2006

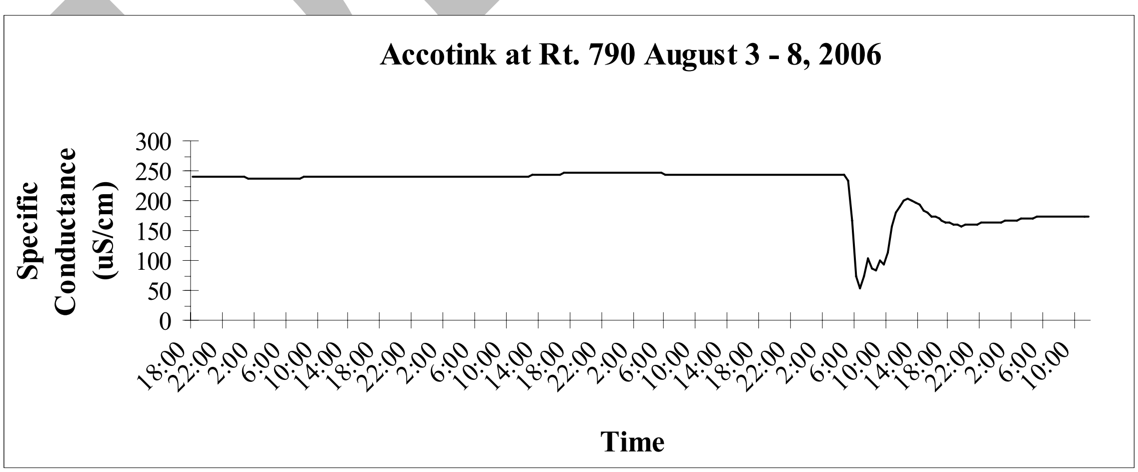

Figure 3-31: Continuous Ambient Monitoring of Specific Conductance in Accotink Creek in August of 2006

3.1.8 Fish Tissue and Sediment Contamination Monitoring Program

VADEQ collects fish tissue and sediment data for two or three river basins per year. The data are used by VADEQ to assess the environmental quality of Virginia's waters and by the Virginia Department of Health (VDH) to determine the need for fish consumption advisories. The monitoring program consists of a two-tiered sampling program. Tier I is a screening study that includes a high number of sampling stations in order to recognize areas of streams with contaminated stream sediment and fish tissue. If Tier I shows areas of contamination, a more intense study (Tier II) is conducted to determine the magnitude and geographical extent and potential source(s) of contamination in the sediments and fish.

VADEQ collected both sediment and fish tissue samples at one monitoring station (1AACO004.86) in the Accotink Creek watershed on two separate occasions, 6/20/2001 and 6/1/2004. Additional fish tissue samples were collected two additional stations in the watershed in September of 2007 – one located on Lake Accotink (1AACO012.78) and one located downstream of the lake (1AACO012.58). The collected sediments and fish tissues were analyzed for PAHs, PCBs, and metals, and then compared to VADEQ Screening Values (risk based approach conforming to EPA guidelines) (VADEQ, 2007).

The sediment and fish tissue samples were analyzed for PAHs, PCBs, and metals. **Table 3-11** depicts the constituents analyzed by VADEQ in the sediment and fish tissue samples. Fish tissues were obtained from three fish species representing top-level predators, mid-level predators, and bottom feeders.

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Table 3-11: Constituents Analyzed in Sediment and Fish Tissue Samples		
	Constituents in Sediment	Constituents in Fish Tissue*
PAHs	Total PAHs, naphthalene, 2-methyl naphthalene, 1-methyl naphthalene, biphenyl, ace-naphthylene, ace-naphthene, dibenzo furan, 2.3.5-trimethyl naphthalene, fluorene,dibenzo thiophene, phenanthrene, anthracene, 1-me phenanthrene, fluoranthene, pyrene, benza anthracene, chrysene, benzo (b) fluoranthene, benzo (k) fluoranthene, benzo(e) pyrene, benzo(a) pyrene, perylene, indeno(1,2,3-cd) pyrene, db(a,h) anthracene, and benzo(ghi) perylene	
PCBs	Total PCBs, Total Chlordane, Sum dichlorodiphenyldichloroethylene (DDE), Sum dichlorodiphenyldichloroethane (DDD), Total dichloro-diphenyl-trichloroethene (DDT), Sum DDT, Heptachlor epoxide, gamma BHC, Total BHC, Endrin, Endrin Aldehyde, HCBs, OCDDs	Total PCBs, Total Chlordane, Sum dichlorodiphenyldichloroethylene (DDE), Sum dichlorodiphenyldichloroethane (DDD), Total dichloro-diphenyl-trichloroethene (DDT), Sum DDT, Total BDE, HCB, Heptachlor epoxide, Aldrin, Heptachlor, delta BHC, gamma BHC, Total BHC, Mirex, Dicofol
Metals	aluminum, silver, arsenic, cadmium, chromium, copper, mercury, nickel, lead, antimony, selenium, thallium, zinc	arsenic, cadmium, chromium, mercury, lead, selenium
* fish tissues from the following species: Redbreast Sunfish, American Eel, White Sucker, Yellow Bullhead Catfish		

No exceedances of the screening values were found in the sediment. However, exceedances of measured constituents in fish tissue were found and presented in the following summary.

Fish Tissue

- Concentrations of heptachlor epoxide found in the tissue samples from American eels (37.34 ppb) were greater than VADEQ's screening value (10 ppb) in the June 2001 sample at 1AACO004.86.
- Concentrations of total PCBs found in the tissue samples from American eels (201.86 ppb) were greater than VADEQ's screening value (54.0 ppb) in the June 2001 sample at 1AACO004.86.
- Concentrations of dieldrin found in the tissue samples from American eels (25.77 ppb) were greater than VADEQ's screening value (6.7 ppb) in the June 2001 sample at 1AACO004.86.
- Concentrations of total PCBs found in the tissue samples from gizzard shad (92.11 ppb) were greater than VADEQ's screening value (54.0 ppb) in the September 2007 sample at 1AACO012.78.
- Concentrations of arsenic found in the tissue samples of yellow bullhead catfish were greater than VADEQ's screening value in September 2007 at 1AACO012.58.

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- Concentrations of mercury found in the tissue samples of bluegill sunfish (0.37 ppm) and tissue samples from two largemouth bass (0.78 ppm and 0.43 ppm) were greater than VADEQ's screening value in the September 2007 at 1AACO012.78.

3.1.9 Toxicity Testing

Toxicity testing using fathead minnows (*Pimephales promelas*) and water fleas (*Ceriodaphnia dubia*) was performed on water samples collected in Accotink Creek by VADEQ. Fathead minnow testing was conducted over 7 days in October of 2005, using water samples from stations 1AACO004.84 and 1AACO006.10. The EPA Region 3 laboratory in Wheeling, West Virginia performed the chronic toxicity testing. Results indicated that water flea mortality and reproduction in the Accotink Creek water samples were not statistically different than that of the control samples. Based on the toxicity testing, there were no toxic water column effects to *Ceriodaphnia* in the Accotink Creek samples.

The toxicity testing indicated that water samples from the Accotink Creek station 1AACO004.84 had adverse effects on fathead minnow survival and biomass. The EPA Region 3 laboratory in Wheeling indicated that in their professional judgment, these results "were probably biologically significant," and that the observed toxicity testing results should be compared with other water quality data collected at this site to determine the causes of toxicity. The effects of water samples from station 1AACO006.10 on fathead minnow survival were statistically different from lab samples, but there was no significant effect on minnow biomass. Biologists concluded that these results for station 1AACO0006.10 "may or may not be indicative of a toxic effect."

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3.2 Discharge Monitoring Reports

Discharge Monitoring Reports (DMR) for each of the individual Virginia Pollutant Discharge Elimination System (VPDES) permitted facilities discharging into the Accotink Creek watershed were obtained and analyzed. Permit information, limits, DMR data, and a summary table of exceedances are presented in **Table 3-12**. The following list summarizes exceedances at permitted facilities:

- VA0001942 had 2 exceedances for TSS on outfall 001
- VA0001988 had 1 exceedance for PH on outfall 001
- VAG830091 had 1 exceedance for PH on outfall 001
- VAG110046 had 2 exceedances for PH on outfall 001

Table 3-12: VPDES Permit Exceedances in the Accotink Creek Watershed

Permit No.	Facility Name	Parameter	Outfall	No. of Exceedances
VA0001942	Kinder Morgan	TSS	001	2
VA0001988	Motiva Springfield	pH	001	1
VAG830091	US Army – Fort Belvoir	pH	001	1
VAG110046	Newington Concrete Corporation	pH	001	2

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3.3 Other Monitoring Efforts

From December 2005 to March 2008, EPA and the United States Geological Survey (USGS) monitored a restored portion of Accotink Creek in the northern part of the watershed (**Figure 3-32**). This monitoring was intended to show the effectiveness of the restoration activities on instream water quality. Continuous and discrete water quality monitoring was performed both before and after the restoration by EPA and USGS. Monitoring consisted of water quality measurements for pH, temperature, turbidity, conductivity, water depth, and water velocity at locations upstream and downstream of the restoration. In addition, there was monitoring for other physical, chemical, and bacteriological parameters during dry weather. Physical habitat monitoring was also performed prior to restoration and biological collections of macroinvertebrates were made both before and after.

As a result of the monitoring, the restored portion of Accotink Creek was listed as impaired for the aquatic life use in Virginia's 2008 Integrated Report. The new impaired segment on Accotink Creek, 0.85 miles long, begins at the confluence with an unnamed tributary located in Ranger Park and continues downstream until the confluence with Daniels Run.

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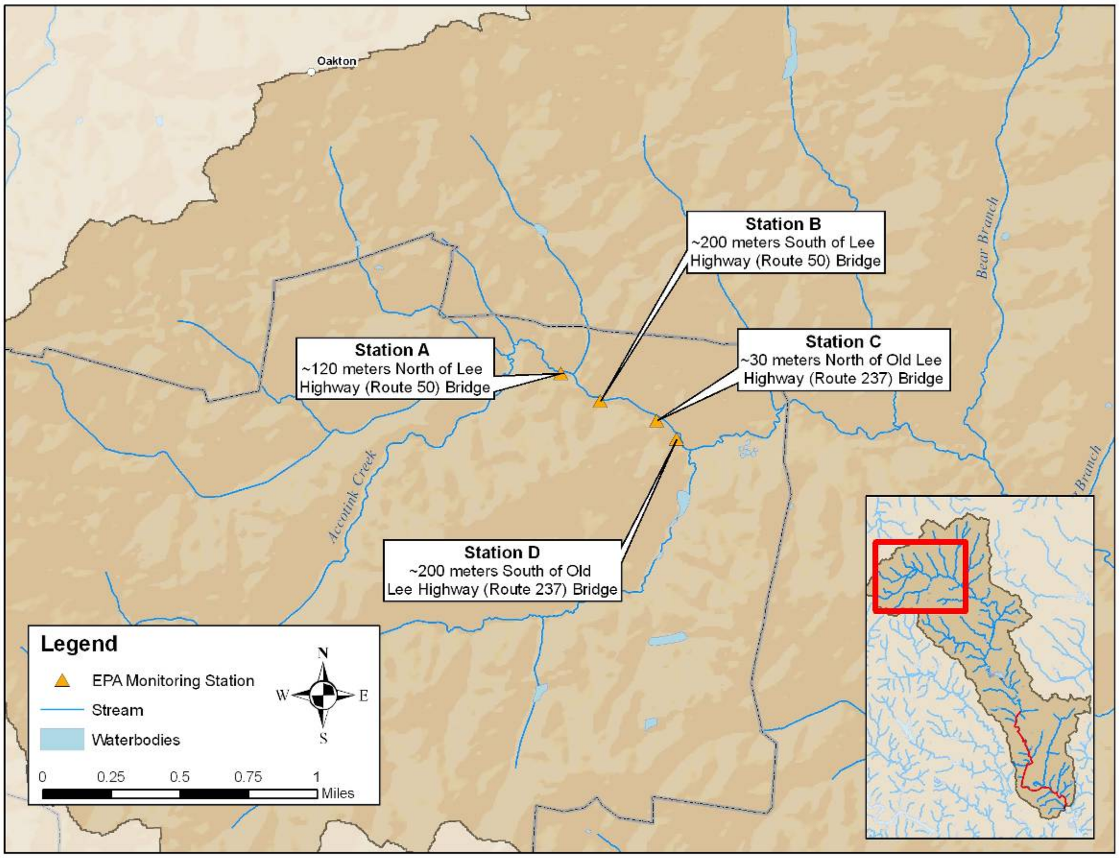

Figure 3-32: Locations of the EPA Monitoring Sites

3.3.1 Water Quality Results

The changes in continuously monitored pH, temperature, turbidity, and conductivity were similar to those seen prior to restoration and were mainly induced by seasonal effects or natural climatic events. Flow data, while not reliable, did not change from pre-restoration measurements except where a monitoring station was moved to a new location. USGS sampling revealed no detectable change in the transport of sediment or bacteria and instream turbidity levels were similar before and after restoration.

The discretely monitored samples showed some differences. The wet weather SS increased significantly after restoration (statistically significant) from 3 – 13 mg/L (before) and 97 – 291 mg/L (after) at the downstream location. Also, TPO43-, NH3, and TKN concentrations did increase slightly after restoration, but the change was not large enough to show that the restoration activities were the cause (not statistically significant).

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Statistical analysis showed there is no statistically significant difference between levels of bacteriological constituents of fecal coliform, enterococci, and E. coli before and after restoration as well as upstream and downstream of the restoration. Changes were only seen between wet and dry weather samples. Therefore the restoration project had no effect on these parameters.

The restoration of the stream bank and channel seemed to have no real effect on the water quality of the Accotink Creek and neither aquatic habitats nor stream bed conditions seemed to see any improvement. SSC, SS, COD, total phosphate, total nitrogen, and ammonia concentrations after the restoration activities were similar to those measured before the restoration.

3.3.2 Biological Monitoring Results

Macroinvertebrate samples were collected by U.S. EPA in 2005, 2006, and 2007 and the stream water quality was evaluated based on the Virginia Stream Condition Index (VASCI), the Hilsenhoff Biotic Index (HBI), number of Emphemeroptera, Plecoptera, Trichoptera (EPT) taxa families, and number of total taxa families for all sampling events. **Table 3-13** and **3-14** show the results. VASCI scores less than 60 mean impaired conditions for macroinvertebrates. The HBI evaluates levels of nutrients or organic content with high levels falling at least in the "enriched" range of 4-7. Although the data was limited, the seasonal changes in the VASCI and the HBI that occurred before and after restoration treatment were not statistically significant and indicated that restoration was not a factor. According to VASCI scores, the restored area does not seem to have been improved by the restoration. Overall though, two years after the restoration all sites showed a small increase in VASCI, HBI, and the EPT taxa index indicating a slight improvement in conditions between pre- and post- restoration. These changes in VASCI (P=0.014), HBI (P=0.012) and total number of EPT taxa families (P=0.017) were statistically significant and the change was greater than would be expected by chance hinting that the restoration might have played a part in the improvement. The VASCI and HBI scores while showing an upward trend were still well within the ranges indicating impairment and enrichment.

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Table 3-13: Results of Macroinvertebrate Data

	Date	Species	Site A (~120 m North of Lee Hwy) Upstream	Site B (~100 m South of Lee Hwy) Restoration Area	Site C (~10 m North of Old Lee Hwy) Restoration Area	Site D (~200 m South of Old Lee Hwy) Downstream	Site RUP (~50 m West of Bridge at River Road) Upstream
Pre-Restoration	11/03-04/2005	VASCI	21.2	29.1	24.3	25.9	-
		HBI	6.86	5.87	5.94	6.06	-
		# of EPT Taxa Families	1	2	1	1	-
		# of Total Taxa Families	5	6	5	5	-
	12/07-08/2005	VASCI	21.5	25.1	30.7	25.6	28.5
		HBI	5.91	6.17	6.03	6.13	5.95
		# of EPT Taxa Families	1	1	1	1	1
		# of Total Taxa Families	5	5	9	6	6
	3/13-14/2006	VASCI	25.2	23.9	26.3	27.2	24.2
		HBI	6.03	6.82	6.03	6.59	6.13
		# of EPT Taxa Families	2	1	1	1	1
		# of Total Taxa Families	5	5	6	6	8
Post-Restoration	9/21/2006	VASCI	36.8	28.2	33.5	32.2	38.6
		HBI	6.02	5.9	5.75	5.71	5.28
		# of EPT Taxa Families	3	2	2	2	3
		# of Total Taxa Families	5	4	7	6	4
	11/15/2006	VASCI	29.6	26.6	28.4	24.8	33.3
		HBI	5.35	6.09	6.03	5.98	5.79
		# of EPT Taxa Families	2	1	2	1	2
		# of Total Taxa Families	6	5	7	5	10
	5/9/2007	VASCI	27.9	22.8	12.3	22.2	26
		HBI	6.09	6.59	6.02	6.79	6.08
		# of EPT Taxa Families	3	1	0	2	2
		# of Total Taxa Families	7	5	3	5	6
	9/18-19/07	VASCI	32	30.5	22.5	31.7	32.2
		HBI	5.9	5.93	6	5.86	5.84
		# of EPT Taxa Families	3	2	2	2	2
		# of Total Taxa Families	6	7	8	7	7
	11/14-15/07	VASCI	27.1	28.5	30.4	29.2	28.8
		HBI	6.47	6.02	6.13	5.97	6.16
		# of EPT Taxa Families	1	1	1	1	1
		# of Total Taxa Families	6	7	8	6	9

Table adapted from Evaluation of Receiving Water Improvements from Stream Restoration (Accotink Creek, Fairfax City), VA Report, 2008.

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Table 3-14: Results of Macroinvertebrate Data Average Macroinvertebrate Indices and EPT Taxa Families Before and After Restoration

	Site RUP		Site A		Site B		Site C		Site D	
	Pre	Post	Pre	Post	Pre	Post	Pre	Post	Pre	Post
VASCI	26.4 (3.)	31.8 (4.8)	22.6 (2.2)	30.7 (3.9)	26.0 (2.7)	27.3 (2.9)	27.1 (3.3)	28.7 (4.6)	26.2 (0.9)	28.0 (4.4)
HBI	6.04 (0.13)	5.83 (5.83)	6.27 (0.52)	5.96 (0.41)	6.29 (0.49)	6.11 (0.28)	6.17 (0.32)	5.99 (0.14)	6.26 (0.29)	6.06 (0.42)
EPT Taxa Families	1.00 (0.0)	2 (2.00)	1.33 (0.58)	2.40 (0.89)	1.33 (0.58)	1.40 (0.55)	1.00 (0.0)	1.40 (0.89)	1.00 (0.0)	1.60 (0.55)

Table adapted from Evaluation of Receiving Water Improvements from Stream Restoration (Accotink Creek, Fairfax City), VA Report, 2008; Parentheses indicate standard deviation

Restoration caused no change in the total number of macroinvertebrate taxa, macroinvertebrate individuals, and percent dominant taxa upstream and downstream and before and after restoration. However, after restoration the composition was affected with more Hydropsychidae than Chronomidae, where as before there were more Chronomidae than Hydropsychidae.

Stream channel cross section and pebble count measurements were taken before and after and upstream and downstream of the restoration. Following restoration, the depth of the upstream reach did not change although there was an increase in depth at the restored location. Even though there was a slight increase in sediment size downstream of the restoration reach, overall there was little change in size after restoration.

Statistically significant changes in VASCI, HBI, and EPT taxa were seen after completion of the restoration project. While VASCI, HBI, and EPT taxa scores improved, they were still well below the level of impairment which signifies that the Accotink still had poor water quality. Most macroinvertebrate parameters such as total abundance, total number of individuals, and dominant species did not change pre- and post-restoration thereby indicating that stream conditions two years after restoration were the same as those found before. According to USGS data, turbidity, sediment size, and flow levels were not affected by the restoration and occurred at the same levels as prior to restoration. Although the restoration was able to stabilize and improve stream banks, the project was not able to provide better conditions and habitat for aquatic organisms and allow for biological community improvement. No changes or improvements were made to stormwater runoff volumes and flow velocities and associated pollutants with this restoration project.

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4.0 Stressor Identification Analysis

TMDL development for a benthic impairment requires identification of the pollutant stressor(s) impacting the benthic macroinvertebrate community. Stressor identification for the biologically impaired segment of Accotink Creek was performed using the available environmental monitoring and watershed characterization data discussed in previous sections. The stressor identification follows guidelines outlined in the EPA Stressor Identification Guidance (EPA, 2000).

The identification of the most probable cause of biological impairment in Accotink Creek was based on evaluations of candidate stressors that can potentially affect the river. The evaluation includes candidate stressors such as dissolved oxygen, temperature, pH, metals, organic chemicals, nutrient, toxic compounds, and sediments. Each candidate stressor was evaluated based on available monitoring data, field observations, and consideration of potential sources in the watershed. Each candidate stressor was then classified as one of the following:

Non-stressor: Candidate stressor with data indicating normal conditions, without water quality standard exceedances, or without any apparent impact.

Possible stressor: Candidate stressor with data indicating possible links to the benthic impairment, but without conclusive data to show a direct impact on the benthic community.

Most probable stressor: Candidate stressor with conclusive data linking it to the poor health of the benthic community.

Table 4-1 summarizes the results of the stressor analysis for Accotink Creek:

Table 4-1: Summary of Stressor Identification in Accotink Creek
Non-Stressors
pH
Temperature
DO
Nutrients (Nitrogen, Phosphorus)
Instream Metals
Possible Stressors
Toxicity
Metals and Organic Contaminants in Fish Tissue
Most Probable Stressors
Urban Runoff and Sedimentation (Instream Erosion)

4.1 Non-Stressors

4.1.1 pH

Benthic invertebrates require a suitable range of pH conditions. Although these ranges may vary by invertebrate phylogeny, in general, very high or very low pH values may result in a depauperate invertebrate assemblage comprised predominantly of tolerant organisms. Field measurements indicated adequate pH values in the biologically impaired segment (Section 3.1.4). There have been no observed exceedances of the water quality criterion for pH. Therefore, pH does not appear to be adversely impacting the benthic community in Accotink Creek, and is thus classified as a non-stressor.

4.1.2 Temperature and DO

Benthic invertebrates and other aquatic organisms require a suitable range of temperature and DO conditions to survive in the benthic sediments of rivers or streams. High instream temperature values may result in a depauperate invertebrate assemblage comprised predominantly of tolerant organisms. Decreases in instream oxygen levels can result in oxygen depletion or anoxic sediments, which adversely impact the stream's benthic community. Based on grab and continuous measurements for temperature and dissolved oxygen, data indicated no exceedance of VADEQ criteria. In addition, daily fluctuations observed in continuous measurements of DO and temperatures in Accotink Creek were revealed to be small (Section 3.1.4). For this reason, temperature and dissolved oxygen are considered as non-stressors in the benthic macroinvertebrate community of Accotink Creek.

4.1.3 Nutrients (Nitrogen, Phosphorus)

High ammonia and nitrate levels in combination with high phosphorus levels generally stimulate algal growth, which may result in eutrophic conditions, high organic loading, and decreased dissolved oxygen. These effects may affect the benthic macroinvertebrates present in the stream. Nutrient concentrations observed along the impaired segment of Accotink Creek were low, and do not appear to be resulting in increased periphyton and phytoplankton growth (Section 3.1.4).

Elevated instream total ammonia levels are toxic for organisms in streams. The total ammonia concentrations along Accotink Creek were generally low and did not exceed VADEQ criterion. This means that total ammonia does not contribute to toxicity of the stream.

Therefore, nutrients are considered a non-stressor in the impaired segment of the Accotink Creek watershed.

4.1.4 Instream Heavy Metals

All available dissolved metals data (aluminum, beryllium, cadmium, chromium, copper, iron, lead, manganese, mercury, nickel, selenium, silver, thallium, and zinc) were below the acute or chronic dissolved freshwater criteria specified in Virginia's aquatic life use standards. Therefore, metals do not appear to be a stressor affecting the benthic macroinvertebrates in the Accotink Creek.

4.2 Possible Stressors

4.2.1 Toxicity

In-stream toxicity testing by EPA's Region 3 Laboratory at station 1AACO00.4.84 indicated adverse effects on fathead minnow survival and biomass, and was statistically different from that of control samples. In the professional judgment of the EPA Region 3 Laboratory, the results "were probably biologically significant." EPA emphasized that the results are qualitative in nature, and should be compared with other water quality data collected at this site to determine the causes of toxicity. The effects of water samples from 1AACO006.10 on fathead minnow survival were statistically different from lab samples, but there was no significant effect on minnow biomass. Biologists concluded that these results "may or may not be indicative of a toxic effect."

Based on the data presented above, and the EPA toxicity test results, toxicity is considered to be a possible stressor in the impaired segment of Accotink Creek.

4.2.2 Metals and Organic Contaminants in Fish Tissue

VADEQ collected fish tissue samples at three DEQ monitoring stations in the Accotink Creek watershed (Section 3.1.8). The fish tissue samples were analyzed and compared by VADEQ for PAHs, PCBs, and metals and compared to screening values developed by VADEQ. Based on VADEQ analysis, measurements of heptachlor epoxide, total PCBs, dieldrin, mercury, and arsenic exceeded the screening values for fish tissue. These contaminants may be adversely affecting the benthic community and, therefore, are identified as possible stressors.

4.3 Most Probable Stressor

4.3.1 Urban Runoff and Sedimentation

In the Accotink Creek watershed, the habitat assessment scores indicated marginal to poor scores for epifaunal substrate, embeddedness, sediment deposition, and bank stability. VADEQ field biologists noted the impacts from urban nonpoint and storm sewer runoff were degrading the habitat and potentially inhibiting the health of the aquatic community. An increase in the amount of impervious surfaces may lead to increased overland flow, high flow events, and channel erosion.

The increased imperviousness of urban areas results in less infiltration during precipitation events, and consequently a higher volume of runoff that enters the creek. In fact, the entire Accotink Creek watershed is highly developed. Based on preliminary calculations using NLCD 2001-DOF 2005 land use hybrid data, approximately 83 percent of the watershed is developed. According to the watershed management plan for the City of Fairfax (part of which is within the Accotink Creek watershed) (July 2005), a flow frequency analysis showed that the frequency of high stream flow events increased with increased imperviousness.

The results of the relative bed stability studies conducted by VADEQ in 2008 showed that the actual amount of sediment along the impaired segment of Accotink Creek was well below what is expected from a stream of this type. The studies indicated that altered hydrology has led to a scoured, eroded stream, which left behind a higher than expected median particle size, and fine sediments has been transported out of the upstream reach of Accotink Creek Additionally, sediment eroded from the banks along the impaired segment of Accotink Creek are being deposited downstream close to the tidal boundary (1AACO002.50).

Consequently, the habitat assessment scores indicated that high runoff flows and stream bank erosion were the most probable stressors causing habitat alterations in the Accotink Creek watershed.

4.4 Stressor Identification Summary

The data and analysis presented in this report indicated that pH, dissolved oxygen, temperature, nutrients (nitrogen and phosphorus), and instream heavy metals in the biologically impaired segment of Accotink Creek were adequate to support a healthy invertebrate community, and were not stressors contributing to the benthic impairment.

Toxicity was classified as a possible stressor because VA DEQ data suggests the presence of toxic pollutants in the impaired segment of Accotink Creek. This is supported by the presence of contaminants in fish tissue, and the results of the chronic toxicity tests on fathead minnows. Therefore, toxicity was identified as a possible stressor.

Based on the evidence and data discussed in the preceding sections, urban runoff and instream erosion (sediment deposition) has been identified as a primary stressor impacting benthic invertebrates in the biologically impaired segments of Accotink Creek. Habitat scores indicated decreased habitat quality in the impaired segments due to increased runoff from the surrounding urban environment.